NATIONAL AGRICULTURAL RESEARCH ORGANIZATION (NARO)

FISHERIES RESEARCH INSTITUTE (FIRI)

ANNUAL REPORT

1994

TABLE OF CONTENTS

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CHAPTER 1

GENERAL OVERVIEW OF THE INSTITUTE

Introduction

This is the first annual report of Fisheries Research Institute (FIRI) under the National Agricultural Research Organization (NARO). NARO was formed by a statute of the government of Uganda in 1992 and became fully operational in 1994. NARO is charged with coordinating and managing national agricultural research in crop, livestock, forestry and fisheries. FIRI is one of the research institutes of NARO. It is charged with generating information and technology to facilitate increased and sustainable utilization of aquatic resources.

Historical Background

What is currently FIRI has changed names since it was established by the British colonial government as the East African Fisheries Research Organisation (EAFRO), at Jinja in 1948. It was later renamed the East African Freshwater Fisheries Research Organization (EAFFRO) under the East African Community (EAC). Following the break up of EAC in 1977, it became the Uganda Freshwater Fisheries Research Organisation (UFFRO) which changed to FIRI following the establishment of NARO.

The thrust of research in of the laboratory through 1950s followed a policy of integrating research interests of individual staff members so that new problems, as they arose were tackled. As far as possible, the work undertaken covered the sequence of events from chemical and physical conditions of the water to ultimate growth of the various biotic populations especially fish.

During the 1960s, research was devoted to fish of commercial importance which included the native tilapiines (Ngege), *Bagrus docmac* (Ssemutundu), *Clarias mossambicus* (Male) and *Protopterus aethiopicus* (Mamba). *Lates niloticus* (Mputa) and several tilapiine species were introduced, first in Lake Kyoga in the mid-1950s and in Lake Victoria in the early 1960s to improve stocks of declining species. The changes that followed these introductions have influenced the trend of research since then.

FIRI Mandate and Research Programs

Since the creation of NARO, FIRI has focused on promoting, coordinating and undertaking applied and adaptive research covering five programs: Limnology, Fisheries, Aquaculture, Post Harvest Fisheries and Socio-economics. The information and technology generated by these programs is expected to:

- Increase the supply of adequate and balanced food,
- Sustain supply of raw materials for local industries,
- Stimulate production for export diversification,
- Raise income and quality of life of the people and

- Conserve the natural resource base for sustainable development.

Limnology Program

The limnology program generates information and formulates advice required for protection of water quality essential for fisheries production and other social benefits. The program undertakes research to understand the physical, chemical, and biological / ecological interrelationships in the water environment, which facilitate balanced growth and production of plant and animal life for ultimate goal of increased and sustainable fish production.

Fisheries Program

This generates knowledge required in formulation of development and management policies for enhancing increased and sustainable fish production. This includes information in biology and ecology of the fishes, the magnitude and changes in fish stocks and fish species diversity, critical habitats for fish survival, the impact of human exploitation especially fishing gears and methods on fish stocks and socio-economic aspects of the fishing industry.

Aquaculture Program

The program generates knowledge required in supplementing natural fish production by the growing of fish in ponds. It determines, selects and breeds suitable fish species, determines suitable environmental conditions for aquaculture, develops suitable feeds and management packages for the promotion of aquaculture activities with fish farmers.

Post Harvest Fisheries Program

The goal of this program is to generate knowledge that will be used to reduce post harvest losses and improve fish quality by studying post-harvest handling, processing, storage and marketing of fish and fishery products.

Socio-Economics Program

The socio-economic program cuts across the above four programs. Its over-all objective is to generate knowledge about the socio-economic impact of communities on the water resources and enhances their capacity to manage and utilise the resources optimally and on a sustainable basis.

Other organisational arrangements

In addition to organising the institute on the basis of programs, the institute has the following committees:

- The Scientific Committee
- The Finance Committee and
- The Housing Committee

Main activities during 1994

The main activities during the year included:

- recruitment of personnel,
- identification of production constraints and research priority setting,
- field and laboratory research,
- training of personnel and
- Rehabilitation of infrastructure.

Recruitment of staff

A total work-force of 114 were recruited from UFFRO, Kajansi Aquaculture Station and the Fisheries Food Technology Laboratory. These included: The Director, Senior Principal Research Officer (1), Principal Research Officers (2), Senior Research Officers (6), Research Officers (6), Research Assistants (10), Technical Staff including laboratory Technicians, Marine Engineer(35) and support staff (53).

Identification Production Constraints and Prioritisation of Research Commodities and Constraints

The Director and the program leaders participated in the NARO prioritisation process at Mweya Lodge March 21 - 27th, 1994. This meeting identified and prioritized the commodities and constraints that were to be researched by the institute. These are given in Tables 1 and 2. The first meeting of the FIRI Program Planning and Review Committee took place at Sunset hotel, July 26 - 27th 1994. The committee re-examined the constraints on the basis of which the research project to be carried out by the institute were to be drawn.

Table 1. List of Commodities (Harvested Species) in order of priority

Commodity	1994 Score
Oreochromis spp (Tilapia)	9.66
Lates niloticus (Nile perch, Mputa)	9.09
Rastrineobola argentea (Mukene)	8.68
Bagrus docmac (Semutundu)	7.90
Haplochromis spp. (Nkejje)	7.58
Clarias gariepinus (Male)	7.54
Hydrocynus spp. (Tiger fish)	7.49
Protopterus aethiopicus (Mamba)	7.56
Cyprinus carpio (Mirror carp)	7.18
Alestes spp. (Nsoga)	7.06

Mollusca spp. (Bisonko)	6.70
Labeo victorianus (Ningu)	6.68
Crocodilus niloticus (Crocodile)	6.64
Barbus spp. (Kisinja)	6.47
Synodontis spp. (Nkolongo	6.08
Crustacea	6.05
Mormyrus kannume (Kasulu)	5.87
Chaoborus spp & Chironomid spp. (Lake flies)	5.84
Oncoryncus mykiss (Rainbow trout)	5.80
Schilbe intermedius (Butterfish, Nzere)	5.39
Auchenoglanis spp. (bubu)	5.18
Xenoclarias spp. (Nsonzi)	5.07
Frogs	4.98
Turtles	4.89

Table 2. List of Production Constraints Identified for each program

Program / Constraint	1994 Score
LIMNOLOGY PROGRAM	
Impact of wetlands degradation	2.350
Water weeds	2.306
Micronutrient levels	2.251
Eutrophication	2.203
Declining Aquatic Biodiversity	2.177
Aquatic pollution	2.149
Inadequate understanding of food webs	2.049
FISHERIES PROGRAM	
Overfishing	2.397
Insufficient information on abundance and distribution	2.352
Human interventions affecting aquatic resources	2.324
Declining fish species diversity	2.306

Open access to the fisheries	2.300
Inadequate information on the impact of fisheries production to national economy	2.289
Impact of exotic species	2.279
Inadequate knowledge on the structure and functioning of fishing community	2.251
Insufficient knowledge on population ecology	2.232
Inadequate fishing technology	2.203
AQUACULTURE PROGRAM	
Lack of suitable feed formulation	2.475
Inadequate technology for siting, designing construction of ponds	2.439
Stunting	2.408
Inadequate technology for fish fry production	2.390
Low productivity	2.375
Insufficient knowledge of economic feasibility	2.334
Insufficient knowledge of pests, parasites and diseases	2.327
Limited aquaculture spp and technology	2.251
Water quality characteristics	2.248
POST HARVEST FISHERIES RESEARCH PROGRAM	
Poor preservation	2.488
Poor handling and processing	2.478
Poor storage practices	2.394
Poor packaging and transportation	2.334
Contamination by pathogenic bacteria	2.331
Inappropriate fishing methods	2.319
Consumer ignorance (with respect to quality)	2.218
Production diversification	2.066
Chemical contamination of fish production	1.865

Research Activities and Achievements

Various research activities were undertaken both by the programs and under collaborative arrangements. Detailed reports are given under individual program but the major ones included:

- collection of information affecting lake productivity mechanisms (anoxia, nutrient chemistry, eutrophication, algal and invertebrate production),
- monitoring the spread, biomass and impact of water hyacinth and transfer of biological control technology to Lake Kyoga,
- fish stock assessment especially in Lake Victoria,
- make an inventory and distribution of endangered species,
- package data on fishing gears to facilitate revision of management regulations.
- Rehabilitation of ponds at Kajansi, production of fish fry for farmers and development of suitable feeds.
- Setting up the Post Harvest Station and initiating examination of fish preservation, handling, processing, packaging and contamination by pathogens and micro-organisms

Training

FIRI scientists of various categories undertook long, medium and short term studies at different institutions within and outside the Uganda. One officer completed a PhD program, three officers started or continued with PhD programs, five research assistants started MSc training at Makerere and other officers took short term training. Member of staff also participated in International, Regional and National workshops, and shows. These are listed in Appendix 1.

Publications

The African Journal of Tropical Hybrobiology and Fisheries which had ceased publication in 1977 following the collapse of EAC resumed with financial assistance from EU. Member of staff published brochures for use by stakeholders. Other publications were made in local and international journals. The publications are listed in Appendix 2.

Funding of research in FIRI

Most of the funds for operations of the institute were provided by government through recurrent and development budget. Additional funds were provided by donor agencies which included the World Bank, International Development Research Centre (IDRC), European Union (EU), the USA and Swiss National Science Foundations, UNESCO and others. FIRI is grateful to the above institutions for facilitation to carry out research, improve and rehabilitate infrastructure and train staff.

International and Regional Cooperation and Collaboration.

During the year, FIRI was choosen to house the headquarters of the Lake Victoria Fisheries Organisation (LVFO) which will be coordinating fisheries management and research on Lake Victoria. In addition, FIRI will be the headquarters of the EU funded Lake Victoria

Regional Fisheries Project.

Visitors

The institute received many foreign and local visitors (Appendix 3). They included members of the NARO board, NRC sectoral committee on agriculture, missions and scientists from various international and regional institutions such as the World Bank, EU, IDRC, DANIDA and collaborators from various institutions and universities.

Major plans for the year 1995

Continue the major activities started in 1994 especially:

- Collect further information on lake productivity mechanisms (nutrient chemistry, eutrophication, algal and invertebrate production).
- Continue monitoring the impact of water hyacinth and to guide adjustment of control measures.
- Intensify the stock assessment and fish species biodiversity studies.
- Package data on fishing gears to facilitate revision of management regulations.
- Continue rehabilitation of ponds at Kajansi, production of fish fry for farmers and development of suitable feeds.
- Continue examination of fish preservation, handling, processing, packaging and examination of contamination by pathogens and micro-organisms
- Ensure that all research assistants have started their MSc training and set a program for training of technicians and other members of staff.

CHAPTER 2

2. LIMNOLOGY PROGRAM

Background

The mandate of FIRI is to focus research towards increased and sustainable fishery productivity thus water is considered by the Limnology Program in terms of its role as a medium that facilitates aquatic productivity with particular focus on fish production. The program persues research on the physical, chemical and nutrient parameters of water essential for balanced growth and production of plant and animal life; and on the biological and ecological inter-relationships which facilitate fish production. The program also seeks to identify the major environmental constraints and man-induced impacts that influence fishery productivity in the water bodies of Uganda and attempt to develop remedial procedures.

Priority research areas

During the year Priority research areas for the Limnology Program were defined according to NARO prioritisation process to cover the following constraints in order of importance:

High priority

- wetland degradation
- water weeds - water hyacinth
- macronutrient levels

Medium priority

- eutrophication
- declining aquatic biodiversity
- aquatic pollution
- understanding of food webs

Program objectives

While priority focus was placed on the first three constraints during the year under review, all the objectives developed for the entire range of constraints are given here. To address the above priorities the following research objectives were developed for the program.

- assessment of the relationships between shoreline-wetland vegetation, water quality and fish production.

- determination of the distribution biomass and movement of water hyacinth.

- determination of the impact of water hyacinth on the water environment, aquatic biodiversity and fishery resources; and on the social and economic activities at the lakeshore.

- transfer biological control technology for use in the control of water hyacinth in Uganda.

- determine if and how productivity of algae influences water quality and fish production.

- conduct research on physical, chemical and biological aspects of water quality likely to influence algal productivity and hence fish production.

- determine the diversity, distribution, biomass and dynamics of major aquatic invertebrates and assess their role in fish production.

Projects in the Limnology Program

The following three projects were designed to address the program objectives:

- Wetlands in Fish/Food Production
- Water Hyacinth Research and Biological Control
- Lake Productivity

In this first Annual Report of FIRI under NARO each project is fully outlined in order to define fully the research mission of program. The activities undertaken during the financial year under review and the achievements are then outlined.

2.1. Wetlands in Fish/Food Production

Background

Wetlands are considered as the belt of land and shallow water occupied by specific plant and animal forms, and separated from the typically terrestrial and open water habitats of lakes, rivers and streams. They are thus transitional areas between open water and dry land but also include other inland areas of impeded drainage. Wetlands may also be defined technically as areas under the influence of surface water, whether stagnant or slow-flowing, extending from land up to a depth in the water where light penetrates up to the bottom i.e the littoral zone. Accordingly, wetland areas along the lake/river shore margins include the shallow part of those water bodies, and in the case of Lake Victoria, this area extends up to about 30 - 50 metres from the shoreline.

Bearing the above definition, it is pertinent to point out wetlands research at FIRI has developed to include the concept of the ECOTONES as transitional zones between adjacent ecological systems which do not end abruptly on either side of the boundary especially with respect to the riparian vegetation.

Wetlands are a relatively new focus of research at FIRI, prompted by the deteriorating state of the fisheries and water quality in the lakes, rivers and streams which could not be explained by the usual methods of fisheries management that does not take into account human activity impacts.

Project components

The activities undertaken at FIRI during 1994 under the umbrella of wetland research can be categorised as follows:

- The FIRI/Swiss Ecotone Project,
- The Ecotechnology Project,
- Emerging Wetland Research Proposals,
- Institutional Linkages.

These activities were intended to bring out aspects of applied research at FIRI, in an effort to generate funding from government and from potential donors. Initiatives which had been made over some considerable period were realised in various ways during the year.

The broad objectives of the initiatives undertaken at FIRI during 1994 under the umbrella of wetland research are outlined below.
These objectives were conceived as the major avenue for bringing out aspects of applied research in FIRI's programmes with the hope of attracting funding from the Uganda Government and potential donors. Initiative which had been made over some considerable period of time were realised in various ways during the year.

The FIRI/Swiss Ecotone Project

The project was aimed at understanding the use and protection of water resources in Lake Victoria through sustainable management of the ecotones; in particular, to study the filter efficiency and regeneration capacity of the ecotones, and to find options for the sustainable management of wetlands as an integral part of water supply schemes through peoples' participation.

The Ecotechnology Project

Through a PhD programme which links various institutions (FIRI, Makerere University, the IHE Delft and the Agricultural University of Wageningen), the program was to carry out an applied study of Lake Victoria wetlands focusing on the influence of wetlands in the ecology of fish populations especially the Nile tilapia and on the water quality of the lake.

Emerging Wetland Research Proposals

The following research objectives were also conceived under a
broad framework incorporating several cooperating institutions:

- to develop low-cost biotechnologies for sustainable use of wetlands and aquatic ecosystems by fishing communities,
- to contribute to the improvement of water quality of lakes and rivers through

appropriate wetland management strategies.

- through capacity building and expansion of the information base, to assist the government of Uganda and Lake basin states to develop and integrate wise-use strategies and policies for Lake Victoria, and

- to evaluate the needs and work plans for a possible National Wetlands Research Centre.

Institutional linkages

The project planned to develop mechanisms through which scientific results from research on wetlands could reach user-groups e.g through the Inter-Ministerial Committee on Wetlands and the National Water and Sewerage Cooperation.

Project Activities

Ecotone Project

The three year project cycle finally started after a two year developmental phase. Preliminary assessments of the study area near Jinja were made. A system description comprising of the major elements (system boundary, direct and indirect inflows to the swamp, outflows, the waste water treatment system lay out and the main vegetation types) was made on the natural science investigation side. The socio-economic aspects were covered by investigations on the types of activities the users of the ecotone are involved in as well as incomes generated from these activities.

A visit by several Swiss personnel associated with the project was made. This coincided with the acquisition of several inputs (spectrophotometer, refrigerator, portable kits, autoclave, chemicals, glassware, computers, bicycles, etc) which were a major boost to the studies. As a result, the visit by the Swiss collaborators took in preliminary sampling activities for both the socio-economics and natural science investigations as well as training on aspects of instrumentation with the acquired equipment.

Ecotechnology Project

As a follow-up of the activities of the previous year, 1994 was devoted to consolidation of data including filling gaps in data sets particularly on vegetation and water quality. Analyses were also carried out on sediments associated with different habitats in relation to the vegetation and distances from the shoreline. In order to give insight into what wetlands actually are in relation to lakes and rivers, a review paper "The Lake Victoria Environment - Its Fisheries and Wetlands" was prepared and accepted for publication in the international journal: Wetlands Ecology and Management. A second paper "An Ecological perspective of human activity-induced changes for the Lake Victoria fisheries" was prepared and presented at the Sixth International Congress of Ecology held in Manchester, England during August.

During the period, a series of sampling techniques were used to develop a data base on the quantification of fish biomass associated with various wetland types, and from these data sets, a start was made on correlations between wetland factors and fish populations.

Emerging Research Proposals

The basis of these proposals is the proposal: "Littoral Fish Production Systems and Wetland Ecotone Sustainability in Lake Victoria - building a knowledge base and research capacity in Uganda for the period 1995/2004". By the end of the year, this proposal which had taken 18 months in the developmental phase was finally submitted to the Director General of NARO who endorsed it and provided letters of support.

Institutional Linkages

A major goal of wetland studies at FIRI is to develop technological packages that can be applied to water resources management. During the year, FIRI was effectively represented at various fora of relevance to wetlands. These included the regular Inter-ministerial Committee meetings on Wetlands, and consultations with the National Water and Sewerage Cooperation. In the latter contacts, a study on the effects of pre-settled waste water of Jinja sewage works on papyrus was started in November 1994 as a form of institutional linkage where FIRI provided the advisory and supervisory role.

In view of the importance attached to wetland degradation as a major constraint for lake fisheries and water quality, it is to be hoped that NARO could strengthen FIRI's efforts in the areas of research elaborated in this part of the report. What is particularly essential to recognise is that wetland research at FIRI has taken a long time to evolve to the level where it is recognised as a key component of most programmes at the institute. As the research addresses human activity, it is a leading force in the development of applied technologies to address constraints. From an estimated annual budget of 123m/=, down to a promised ARTP input of 2m/= it is not possible to expect much from the potential for research on wetlands.

Results of Wetland Studies

2.1.1. Wetland vegetation types as indicators of fish habitats in Lake Victoria

By J. S. Balirwa.

Background

Active research on wetlands was initiated early in 1993 as an innovative approach to assess the impact of human activity on the Lake Victoria ecosystem. Wetland buffer zones are considered as a component of the water quality, fisheries and biodiversity of the lake, and studies of wetlands were intended to serve as a model for large scale landscape/aquatic resources management. Subsequent recognition by NARO of the importance of wetland buffer zones for the water quality and fisheries of lakes were not translated into financial inputs from government and the results reported for the year 1994 are an outcome of a PhD study programme linking FIRI with Makerere University in Uganda and, the Agricultural

University of Wageningen and the IHE, Delft in The Netherlands.

Methodology

An inventory of the vegetation species contributing to wetland structure was made by field visits along a 110 km long shoreline enclosing about 130 km^2 of surface water in the northern part of the lake region. Shoreline plant species were identified and abundance patterns of the vegetation were determined using indices of abundance and association. Sample sites were selected for in-depth study which included determination of biomass. The wetland landscape in this area was reconstructed and brought to a level of comparison with satellite (SPOT) images of the same area taken during 1993. Water and sediment quality were analysed in relation to the selected habitats defined by dominant vegetation patterns.

Vegetation inventory

There are at least 30 plant species associated with shoreline swamps. For the most part, wetland buffer zones are dominated by *Cyperus papyrus*; other distinct species in particular *Phragmites* (reeds), *Typha* (bulrush/cattail) or *Vossia* (hippo grass) appear mostly as either co-dominants or as locally dominant stands. Disturbed stands show atypical features of vegetation including mixtures of shrubs and herbs especially in areas which have been intensely cultivated or grazed. To the east of this belt, areas of riparian forest including stretches of *Afromomum* and *Phoenix* remain and are associated with low human population densities.

Vegetation Biomass

Biomass estimates of dominant vegetation stands are necessary to determine the efficiency of filtration of incoming run-off water and to understand lag effect influences on organic composition of fish habitats associated with a particular vegetation. The biomass of the various species was determined from fresh weights to ash free dry weights of papyrus, *Phragmites*, *Typha* and *Vossia*. In contrast to what might be expected from fresh weights, the biomass of papyrus is less than that of *Vossia* or *Typha*.

Water Quality and Sediment types

Water types as defined by electrical conductivity (a measure of ionic content) does not vary widely with vegetation types. However, apart from depth differences associated with areas colonised by vegetation types, it was shown that sediment type (clay, sand, silt, etc) and organic content vary with habitats of the vegetation types. Changes in these parameters occur with the influence of human activity and water hyacinth infested areas.

Fish Productivity of Swamps

At least 23 fish taxa were identified from the study areas associated with wetland vegetation. These species are not to be found in the same relative quantities in different vegetation types. Haplocromines are common and, for the majority of the species, the wetland fringe seems

to provide breeding habitats as well as nursery grounds. Data collected during the year show that not all swamps are unproductive. However, a distinction must be made between the stagnant swamp interior and the adjacent water body up to a distance of about 50 m, as well as stream inlets and indentations in the shoreline. Conclusions made from these data are likely to have an important bearing with regard to agricultural and industrial developments, sewage effluents and the wise use of wetlands including the fisheries.

Constraints

Inspite of wetlands being the priority constraint of the limnology programme, no funds have been received to support the various experiments. This is a new project and a lot of inputs are needed if FIRI is expected to follow the prioritised research programmes. Six experiments comprise this project and the 1-2m/= ARTP expected in the next year will not have much impact on the project objectives beyond incidental contributions by other projects. At the present levels of input, the project is unlikely to realise its objectives.

Future work plans

Depending on availability of funds, several experiments which were not carried out will be started i.e productivity measurements, elaboration of human impacts, investigations of fish habitats and water quality in the first 50m, diurnal and seasonal use of wetlands by fish and estimates of fish production per hectare. In view of the increasing influence of water hyacinth on the shoreline vegetation, a survey of this influence will be undertaken.

Ecotone Research

Background

Wetlands in Uganda have for decades been vast and abundant. These wetlands have traditionally been utilised by cultivators, fishermen, firewood and reed collectors, herbalists, hunters and brickmakers. However, a conflict has arisen between the traditional uses and the more recent functions of wetland resources such as the filter capacity which facilitates them to strip effluents from the watershed and hence safeguard adjacent water bodies. The aim of the ecotone research is to resolve this conflict by evolving technologies which promote sustainable use of the wetland resources for both traditional uses and for the management of the water environment.

Activities

The following activities were undertaken during the year under review:

- contacts with local authorities;
- site selection and survey; three swamps in Jinja town namely Loco, Walukuba and Budumbuli were surveyed;
- data on socio-economics was collected by use of semi-structured questionnaires during interviews which covered all aspects of resource users. Respondents were randomly

selected in the three swamps;

- a paper was prepared on "Land and property rights in reference to the swamps in Uganda"

Observations

The swamps are mostly used for agricultural purposes and by of fishermen.

Constraints

- Floods posed threat to researchers because most gardens were inaccessible due to heavy rain.
- Counterpart funds to supplement donor funds for field activities were not available.
- Inadequate transport facilities.

2.2. Water Hyacinth Research and Biological Control Project

Background

The rapidly growing interference by water hyacinth with fishing activities and uses of water such as transportation, washing and drinking by communities and livestock around Lake Victoria and other waterways in Uganda is now a matter for concern and worry. Recent Surveys indicate water hyacinth has the potential of a much worse environmental and socio-economic menace in the nearshore environments around lakes Victoria and Kyoga and the River Nile than is currently envisaged.

The noxious weed multiplies extremely fast, grows rapidly and spreads quickly to form extensive mats which deprive the water under the mat of oxygen and light, hinder primary productivity and limit the distribution and abundance of biodiversity and hence disrupt fishery productivity. Therefore, the spread of water hyacinth continues to put more and more fishermen out of job and livelihood. Further, Water hyacinth already obstructs/fouls water transport, domestic water sources, hydro-electric power generation (in Uganda), touristic and recreational attractions; and the weed may harbour disease vectors e.g. snails that transmit schistosomiasis.

There is, therefore, urgent need to define the impact of water hyacinth proliferation on the water environment and aquatic resources, as well as on resource utilization; and to develop effective control measures.

General Objectives

- The project "Water hyacinth research and biological control" was designed to address two aspects:

- To determine the impact of the rapidly growing interference by the noxious weed with the water environment, aquatic resources particularly fisheries and with the social and economic activities of the lakeside communities;

- To undertake technology transfer research in order to package the use of biological control agents to manage water hyacinth in Uganda.

Specific objectives

During the financial year, the research focus was:

- To determine the extent water hyacinth affects the water environment, aquatic biodiversity and fishery productivity.

- To assess reproductive viability of two biological control weevils namely Neochetina bruchi and Neochetina ichhomiae under field conditions in Lake Kyoga.

Project activites

Impact research

Impact investigations comprised two major activities:

- determination of distribution, cover and biomass as well as the movement of water hyacinth throughout Uganda; and

- assessment of the effects of infestation by water hyacinth on water quality and aquatic biodiversity notably fish.

Methodology

The first set of activities were undertaken through periodic surveys on lakes Victoria, Kyoga and Albert as well as othe River Nile. Periodic surveys are essential for those activities in view of the mobile nature of the water weed and also to appreciate the dynamic dimension of the impact of Water hyacinth. The effects of water hyacith infestation were investigated through regular experimennts at permanent sites as well as by means of data collected during the surveillance field trips.

Observations

Water hyacinth cover and biomass (August 1994)

- about 700 km of the mainland shoreline of the Uganda portion of Lake Victoria, with a biomass estimate of 1,330,000 tons;

- about 50% of the shoreline of Lake Kyoga and 30% of that of Lake Kwania;

- about 500 km of the banks of River Nile - Uganda section, with a biomass estimate

of 330,000 tons;

Environmental impacts

- Severe de-oxygenation occurs under permanent mats inshore. Total oxygen depletion may occur overnight. Production and accumulation of toxic gases like hydrogen sulphide occurs under conditions of severe de-oxygenation especially in the mud below hyacinth mats,

- Significant reduction in algal biomass was measured under the mats,

- drastic reduction in animal life including fish under large resident mats was deduced from findings obtained under hyacinth up to 20m inside the mats. A diversity of fauna was found at the edge of the mats particularly small ones,

- Single species oflow oxygen-tolerant animals e.g. dragonfly larvae and chironomids were found, often in large numbers,

Biological Control

Activities to transfer biological control technology for water hyacinth to Uganda started in 1993 when an entomologist, anaquatic ecologist and two technicians received training on various aspects of the subject including handling, rearing, field release, monitoring and evaluation at IITA Benin. The activities this year were mainly to consolidate broodstock maintenance technology as well as conduct reproductive viability experiments in the field on Lake Kyoga. These activities were caried out jointly by the Water Hyacinth research Team at FIRI and the Biological Control Unit at NAARIwhere the broodstock centre was established.

Outputs

- A small well trained biological control team comprising staff from NAARI, FIRI and Fisheries Department was consolidated.

- An active bloodstock centre for stock maintenance and limited mass rearing of biological control weevils for water hyacinth was established at NAARI.

- Reproductive viability trials for the biological control weevils were successfully completed on Lakes Kyoga. Successful experiments were conducted at over 24 sites scuttered all over the lake.

Constraints

The major constraints were:

- lack of sufficient funds to facilitate the planned construction of lakeside mass rearing facilites to expedite weevil distribution throughout Lake Kyoga and the River Nile; and

- Lack of Regional consent to introduce biological control weevils on Lake Victoria. This prevented initiation of the control measure on the shared lake.

Future Plans

- Activities on Biological Control will concentrate on bloodstock maintenance at NAARI and on mass rearing and release of the biological control agents on Lake Kyoga and on Lake Victoria as soon as regional consent to introduce weevils onto this lake is declared.

- To develop strategy to monitor impact of control processes on water hyacinth, and on how they influence the water environment and the fishery.

- Continue to develop data base on impact of water hyacinth on aquatic resources in time and space as weed proliferation intensifies, until the control processes are well underway.

- To monitor the impact of control processes on the weed, the water environment and the fishery.

2.3. Lake Productivity Project

Background

The Lake Productivity Project focuses on the functioning of the major Ugandan lake ecosystems. The project has several research components, one of which is to examine changes in the productivity mechanisms in Lake Victoria in order to develop management systems that will ensure long-term fishery production of the lakes. In addition, this project generates data on macronutrients levels, physical, eutrophication and algal growth processes and the role of invertebrates in the food-web especially as food for fish. Such information has direct applied value towards the management and rational exploitation of the fisheries and other aquatic resources.

Research emphasis has been on measurement of macronutrient levels, physical (thermal & oxygen stratification), algal growth and eutrophication processes, invertebrate abundance and biomass, in relation to fish production and water quality in Lake Victoria. In addition lakes Kyoga and Albert were studied to facilitate a comparison on water quality effects on fish production

The Lake productivity project collaborates with the University of Michigan USA and Freshwater Institute Canada, through the Lake Ecosystem and Biodiversity Research programs which support an ecosystem approach to aquatic resource management. The activities carried out by Lake Productivity and these collaborating institutes are interrelated and complimentary.

General Objective:

The Lake Productivity broad objective is to carry out limnological sampling, so as to provide timely and continuous information and guidelines on ecosystem-based management with the attention to water quality impacts on the fishery in lakes Victoria, Kyoga and Albert.

Specific Objectives:

- Determine the physico-chemistry relationships and their effects on water quality and fish production, especially, oxygen depletion which causes fish kills and generally affects temporal and spatial fish distribution in the lakes. Nutrient concentrations and their role in the eutrophication of lakes, especially Victoria are evaluated.

- Determine algal primary production, biomass and species composition and evaluate their role as food for fish and if primary production can support fish yield in the lakes. Algal response to nutrients and role lake clarity and in oxygen regimes through photosynthesis and decomposition effects are evaluated. These algal effects on invertebrates (fish food), fish stocks, distribution and production are evaluated.

- Determine the composition, abundance and distribution of zooplankton and macro-invertebrates especially *Caradina nilotica* and evaluate their role as food for fish.

Activities

- To achieve the above objectives the following activities: Physical Hydrolab measurements (conductivities, oxygen, pH, and temperature, light attenuation, Secchi transparency, chemistry sampling, nutrient bioassay experiments, primary production, invertebrates sampling, and *C. nilotica* were done. Lakes Victoria, Kyoga, Nabugabo and Albert were sampled between January and December 1994 are given in the table below.

- Monthly sampling of open regions of Lake Victoria (Bugaia region) and opportunistic sampling on FIRI- EEC Cruises were done. These were sampled for physical parameters, nutrient chemistry and biological production (algal and invertebrate). Algal response to nutrients, zooplankton and macro-invertebrate (benthos) abundance, biomass and secondary production were done. Details of activities carried out are given under different studies\experiments under the project

- Inshore shallow bays of lake Victoria were sampled at least once every two months for same parameters as in (i).
- Lake Kyoga was sampled in May and October 1994 while Lake Albert once May October. It was not possible to sample these lakes quarterly a year as planned due to in adequate funds and irregular funds.

- Rain water collection was done at FIRI and analysis done to determine its composition during the months of January to November 1994.

- Sub-Surface water samples collected a long transect from Port Bell (Uganda) to

Mwanza (Tanzania), aboard a Ferry Wagon were collected and analyzed for nutrients, algal biomass and species composition during March 1994.

- Western Lake Victoria and the Nabugabo lakes (Nabugabo,Kayanja, Kayugi) were sampled during March 1994.

Month	Lake				
	Victoria			Kyoga	Albert
	Bugaia	Inshore	Lake - wide		
Jan.	+++	+++	+++		
Feb	+++	+++	+++		
March	+++	+++	+++		
April.	+++	+++	+++		
May	+++		+++	+++	+++
June	+++		+++		
Jul	+++	+++	+++		
Aug.	+++		+++		
Sept.	+++	+++	+++		
Oct.	+++	+++	+++	+++	
Nov.	+++	+++	+++		
Dec.		+++	+++		

Summary Results January to December 1994

- The annual oxygen concentrations at Bugaia, the deep water station of Lake Victoria, varied significantly with Oxygen concentrations in the mixed layer in the range 6 to 9 mg/L. These high oxygen concentrations in the surface waters were consistent with measurements of higher algal biomass and productivity. Oxygen concentrations in the hypolimnetic waters (35 m and below) were low and for a longer period - January to May and then October to December - values below 1 mg/L. Lake Victoria still mixes in June to July with extended anoxia lakewide, during the months of stratification. The persistent and extensive deoxygenation of the hyplolimnion has apparently affected fish distribution as observed from opportunistic sampling during the fish stock assessment studies.

- In Lake Victoria, the euphotic zone continued to shrink compared to past observations. It was in the range 5 m to 10 m offshore (Bugaia) and twice as shallow in the inshore waters. This was much shallower compared to a mean of 15 m and

5 m observed in 1990-1992.

- Lake Victoria Secchi transparency was of the range 1.0 to 2.3 m at Bugaia during the mixing period of June to July.

- Algal biomass and productivity was high lakewide but higher in the shallow inshore bays than in deep open waters. Minimum algal productivity was observed in July to September corresponding to periods of severe light limitation.

- Composition, distribution and abundance of zooplankton remained generally as reported previously. In Bugaia a new species *Cerodaphnia dubia* was encountered in small numbers. This large bodied species together with the previously reported *D. lumnoltzi* (monacha) provides further evidence of inefficient harvesting of zooplankton at the deeper offshore waters of Lake Victor

- Seasonal variation in abundance of zooplankton at the deep offshore station followed a pattern comparable to that previously reported with a build up of densities during the first quarter of the year. The peak density was in May.

- Stomach content analysis showed that cyclopoid copepods were the major prey item for cyprinid pelagic and *R. argentea* while Chaoborus larvae, pupae and the prawn, *C. nilotica* were the major prey of the cichlid haplochomines.

- Length frequency analysis of cyclopoid calanoid copepods indicated a size differentiation of copepoid developmental stages.

Constraints 1

- Inadequate funds to support all research components and experiments of the project. Funds were insufficient to support quarterly sampling of lakes Kyoga and Albert as planned.

Constraints 2

- Lack of appropriate equipment and e.g. microbalance and gas chromatography to measure nitrogen gas samples and screen phycotoxins.

Constraints 3

- Inadequate manpower to handle all the research components. For example physical limnology which includes meteorological and hydrological data collection, nutrient chemistry, algal primary production and algal taxonomy are being handled by only two research officers instead of four.

Future work plans

- Continue with the Nutrient chemistry, study eutrophication and algal growth processes and invertebrates dynamics to build up an adequate data base required in assessment

of water quality impacts on fish production.

Results of Studies under the Lake Productivity Project

Two collaborative projects operate under the Lake Productivity Project. These are:

- Biodiversity and climate change in East Africa - Lake Victoria IDEAL Limnology project. This project is funded by the USA, National Science Foundation. The principal investigators in this project are Prof. J. T. Lehman from University of Michigan, and Dr.F.W.Bugenyi, R. Mugidde, L. Ndawula & G.Mbahinzireki from FIRI.

Lake Victoria Ecosystems Project: Structure and Function of a Tropical Ecosystem. This project is also funded by NSF. The principal investigators are:

- Professor George Kling, Project Head, University of Michigan
- Dr. F.W. Bugenyi, Director of Research, Rose Mugidde, Research Officer, and Mr. Lucas Ndawula, Research Officer, Fisheries Research Institute, NARO, Jinja, Uganda
- Dr. Anne Giblin, Marine Biological Laboratory, Woods Hole
- Dr. Robert Hecky, Freshwater Institute, Government of Canada
- Professor James Kitchell, University of Wisconsin-Madison
- Dr. Sally MacIntyre, University of California at Santa Barbara
- Dr. Peter Reinthal, Eastern Michigan University

Activities and some results of these two projects are reported below together with results of other studies of the project.

2.3.1. Biodiversity and climate changes in East Africa Lake Victoria IDEAL Limnology Project

Introduction

The Lake Victoria Ideal Limnology operates in conjunction with the Fisheries Research Institute (FIRI) at Jinja. It carries out Research which compliments the FIRI-Lake productivity project.

The great Lakes in East Africa hold within their basins and sediments evidence about thousands of millenia of continental responses to global climate change including the environmental conditions during the evolution of the of the human species. The conditions in the Lake Victoria have changed profoundly in the last three decades with threats to water quality and Lake Biodiversity. The diverse processes, biota and interaction that cause these changes are not clearly understood. For instance, nutrient dynamics especially, phosphates uptake and nitrogen fixation rates and invertebrates and secondary production remain to be known. The overall goal of this research is to answer scientific questions presented by the

Lake Ecosystem with attention to interaction of major physical, chemical and biological processes.

Project broad objectives

- Observational program for quarterly a year sampling to measure physical, chemical and biological (algae and invertebrates) and collect integrated samples for biogeochemical analysis.
- Process oriented experimental studies of finite duration that are intended to provide rate measurements as needed for the development of ecosystem models.

Project Activities

The aim of the lake Biodiversity program was to carry out limnological sampling, including bioassay in the shallow and deep waters of Lake Victoria. To achieve this:

- Quarterly year sampling in offshore and Napoleon Gulf was done to measure physical & chemical Parameters, rates of phytoplankton photosynthesis and nitrogen fixation, nutrient bioassay experiments and invertebrates samples for abundance and secondary production.
- Upgrading the analytical chemistry laboratory at FIRI providing portable equipment that enable field rapid processing of samples (SRP & SRSi) while in the field and achieve high quality results.
- Training of FIRI personnel in new laboratory and field techniques: Operation of Colorimeter, Mini-Spectrophotometer. Nutrient Bioassay experiments and nutrient uptake experiments.
- Provided and assisted FIRI staff to learn computer software packages.

Results

- Rates of phosphates inshore were curvilinear and equilibrium approached within 20 minutes because of high PH turn over rates inshore.

- Increased algal biomass was highest in bioassay experiment with singly N additions, followed by combinations (N,P & Si and lowest in singly P, compared with control treatments.

- Nitrogen fixation rates were high from samples collected inshore shallow bays than open lakes samples,(b) with possible N limitation to algal production especially in deeper waters where light limitation is severe.

- Bioassay experimental additions of nutrients to epilimnion waters are being done and data generated so far is currently being analysed at FIRI.

- Samples collected for particulates are currently being analysed in the US by Prof J.Lehman. These include P,C & N. These analysed are particularly important in determining which nutrient limits productivity and causes eutrophication in Lake Victoria.

- On going measurements of temperature and conductivity profiles using a hydrolab to determine extent of anoxia,the patterns of mixing and stratification in the lake.

2.3.2. Lake Victoria Ecosystems Project: Structure and Function of a Tropical Ecosystem

Introduction

The Lake Victoria Ecosystems Project (LVESP) operates in conjunction with, and under the auspices of, the Fisheries Research Institute (FIRI) at Jinja. The justification for our research program is the need to learn how the Lake Victoria ecosystem is structured and how it functions. This problem is important because, first, Lake Victoria has been transformed in recent years to the point where fisheries and water quality are in jeopardy, and second, because we know very little about aquatic ecosystems in the tropics and how they compare to aquatic ecosystems in the temperate zone. Our overall goal is to determine the rates, variance, and magnitude of critical controls in a tropical environment, in order to solidify or refute current ecosystem theories. We hope to discover what governs the Lake Victoria ecosystem and its response to past and impending changes brought on by eutrophication, climate shifts, and introduced species.

Activities of the Project

- Upgrading the analytical chemistry laboratory at FIRI and improving our ability to rapidly process samples upon return from the field and most importantly to achieve high quality results.

- Installation of a meteorological station at the Jinja Pier.

- Training of FIRI personnel in new laboratory and field techniques, including, alkalinity titration, measurements of low level in situ CO_2 concentrations using a Li-Cor CO_2Analyzer, operation and maintenance of the meteorological station and SeaBird Electronics CTD profiler, the sampling and experimental manipulation of sediment cores using micro-Kuellenberg, KB, and box corers and use of a Magellan Geographical Positioning System.

- Assisting FIRI personnel in the routine collection of samples at the offshore station near Bugaia Island.

- Cross lake cruise in December 1994 to determine the spatial variability of a number of parameters on the lake.

- Samples collected for stable isotopes are currently being analyzed in the US and Canada. These include the $\delta^{13}C$ of DIC, POC and biological materials including, fish, zooplankton, plants, and sediments, as well as the $\delta^{15}N$ of fish, zooplankton, plants, and sediments. These analyses are particularly important in determining the structure of the food web in the lake and most should be completed by March 1996. The $\delta^{34}S$ of sediments and lake water is also being determined at Woods Hole Marine

Laboratory.

- Sediment cores have been collected from Pilkington Bay, Buvuma Channel and 2 offshore sites in Lake Victoria for paleolimnology. These are presently being looked at the Freshwater Institute and the University of Michigan.

- The internal loading of nutrients to Lake Victoria is being determined by laboratory incubations of intact sediment cores. Sediment cores have been collected from Pilkington Bay, Buvuma Channel and 2 offshore sites in Lake Victoria. Cores are held in oxic and anoxic conditions and the release of phosphorus and nitrogen are measured. All respiration measurements have been completed at FIRI and the P and N concentrations are being determined in the US.
- Ongoing measurements of temperature and conductivity profiles using the CTD to be used to determine the patterns of mixing and stratification in the lake and well as mixing and nutrient transport. Currently the data has been downloaded at FIRI and initially processed there. Other analyses are done by Dr. MacIntyre to model these processes. These parameters are measured every 6 weeks at a number of inshore sites from Napoleon Gulf to Pilkington Bay as well as at as many offshore sites as is possible.

- Working in conjunction with Wetland\Ecotone team, samples collected from the wetlands are being analyzed for stable isotope.

Results of Project during 1994

- Field and laboratory experiments have shown that: (a) the return of nitrogen from the sediments to the water column is more pronounced that the return of phosphorus; (b) there is some limitation of algal production by low levels of CO_2 both inshore and offshore; (c) there is movements of water (and nutrients) from inshore regions such as bays, to inshore channels that connect with the offshore regions.

- Stable isotope studies of $\delta^{13}C$ of DIC and POC indicate greater production occurring inshore than offshore suggesting that the drawdown of CO_2 could be a potential factor limiting lake primary production in the water column.

2.3.3. Physico-chemical effects and algal growth on water quality and fish production

By F.W.B. Bugenyi, R. Mugidde, M. Magumba & P. Nyonyitono.

Background

Physico-chemical and algal research on Lake Victoria was initiated in 1990 to assess the apparent changes in nutrient chemistry, algal biomass, production and species composition at that time, which affect fish production. Results obtained facilitated a comparison of current observation to the historical limnological data base of mixing regimes, nutrient concentrations, phytoplankton abundance and productivity. Studies carried out indicate that: Lake Victoria has eutrophied with changes in nutrient chemistry, reduced lake transparency,

pronounced and prolonged hypolimnetic anoxia, elevated phytobiomass and algal productivity, frequent algal blooms associated with fish kills and dominance of blue green algae (cyanobacteria) most of the year. These observations indicate a deteriorating water quality, especially anoxia which reduces the habitable fish volume, and puts at risk the fishery, especially the remnants of the benthic haplochromine species throughout the lake.

Physico-chemistry

Thermal stratification was observed in Lake Victoria in January to May and in August to December 1994. The distribution of oxygen over depth was strongly affected by the annual cycle of thermal stratification. Oxygen concentration were < 1 mg liter^{-1} in the hypolimnion most of the year. However, during the months of deep lake mixing (June to July) oxygen was in the range 5 to 6 mg liter^{-1} in 60 m depth. Lake Kyoga due to its shallow depth mixes all year round, while Lake Albert exhibits weak thermal and oxygen stratification in the deep open waters.

Light attenuation in Lake Victoria was rapid in inshore (mean 1.0 lnm^{-1}) than in offshore(mean 0.5 ln m^{-1}) waters during 1994. Seasonal changes in Secchi depth transparency were observed in the deeper water of Lake Victoria and was > 2 m in June-July, the period of deep lake mixing. The euphotic depth increases synchronously with the Secchi depth, being deepest (7 -8 m) in June-July. This euphotic depth was, however, unusually shallow compared to 10 m to 29.2 m observed in previous years (1991-93) at the same period of the year. There was a high correlation between particulate organic matter, especially algal biomass(chlorophyll-a) and the Secchi transparency (R^2 = 0.80). Lower lake transparency was associated with dense algal blooms which reduced light penetrations to deeper depth in Lake Victoria. Lake Kyoga showed horizontal differentiation in physico-chemical parameters. Secchi transparency for instance, was highest in Bbangala (mean 1.0 m) and least in Muntu and Muswakire(mean 0.6 m). Lake Albert waters were much clearer than those of lakes Victoria and Kyoga with Sechhi transparency in the range 1.8 m to 4 m lake wide.

Algal biomass in the inshore areas of Lake Victoria was in the range 30 to 80 mg.m^{-3} and half as high in the deeper offshore waters at Bugaia. Further evidence of higher algal abundance in the bays than in open waters was obtained from observations done a long a transect from Portbell (Uganda), through the deep open waters, to the shallow inshore bays in Mwanza(Tanzania). Lakes Kyoga and Albert exhibited lower algal biomass in the range 5 to 25 mg.m^{-3} and 2 to 20 mgm^{-3} respectively.

The in situ algal volumetric production profiles of Lake Victoria were shallower than those of Albert and Kyoga, reflecting the rapid underwater light attenuation typical of the eutrophic Lake Victoria. Offshore Lake Victoria areal algal production was in the range 8 to 18 $gO_2.m^{-2}.d^{-1}$ and was twice as high in the inshore shallow bays of Pilkington Bay, Napoleon Gulf and Buvuma channel. Lower algal production was observed in September associated with a phytoplankton crash (mean chlorophyll 5.4 mg.$^{m-3}$) unlike the previous years of a September-October major maximum algal production. Algal production in Lake Victoria was severely light limited most of the year especially in deeper offshore waters due to self shading and a deeper mixed depth. Substantially increases in integral production was not achieved, a trend which threatens the sustainability of the current high fish yields in Lake Victoria. Relatively lower production was observed in Lake Albert and Kyoga compared to

stations of similar depth in Lake Victoria.

Lake Victoria's algal flora was dominated by blue green algae throughout the year, while lakes Kyoga and Albert had higher proportions of green algae than Victoria. The low concentration of dissolved inorganic nitrogen in Lake Victoria seem to select for the heterocystous nitrogen fixing cyanobacteria that now dominant the phytoplankton of Lake Victoria. This proliferation of the non digestible, potentially toxic blue green algae in Lake Victoria are a threat to fish production. The diatom assemblage of the three lakes is quite different. Diatoms *Cyclostephanodiscus* and *Cyclotella* were regularly seen in Lake Albert, while *Melosira* was present in Lake Kyoga but absent and replaced by *Nitzchia* in Lake Victoria.

Nutrient bioassays enriched by addition of nitrogen increased in algal biomass (chlorophyll-a) in respect to the control at both the inshore and offshore stations. No much differences were demonstrated by phosphorus nor silica additions or a combination of the three. This suggests that algal growth in Lake Victoria may be limited by nitrogen. Further evidence of nitrogen limitation was obtained from the high rates of nitrogen fixation and high nitrogen uptake by algae. Phosphorus debt was low and negligible in the deeper open lake samples due to the excess phosphorus concentrations in Lake Victoria.

Constraints

Inadequate funds to support all research components and experiments of the project. Funds were insufficient to support quarterly sampling of lakes Kyoga and Albert as planned.

Constraints

Lack of appropriate equipment and eg microbalance and gas chromatography to measure nitrogen gas samples and screen phycotoxins.

Constraints

Inadequate manpower to handle all the research components . For example physical limnology which includes meteorological and hydrological data collection, nutrient chemistry, algal primary production and algal taxonomy are being handled by only two research officers instead of four. This is a gross research over load.

Future work plans

Continue with the Nutrient chemistry, study eutrophication and algal growth processes.

4.3.4. Zooplankton Communities of Lakes Victoria, Kyoga and Albert

By Mwebaza-Ndawula, Lucas

The main objective of this study was to monitor the composition, distribution and abundance patterns of zooplankton in the various lakes and relate them to fish production. Investigations were carried out on Lakes Victoria Kyoga and Albert. Samples from Lake Victoria were taken from three inshore shallow water stations (Napoleon Gulf, Buvuma Channel and Pilkington Bay) and one open, deep water station (Bugaia). The latter station was sampled monthly as much as possible while inshore stations were sampled quarterly. Lake Kyoga was sampled twice: in May and October while Lake Albert was sample once in May. At all sites samples were taken with the use of conical nets with 0.5m mouth opening. Nitex net meshes of 60um and 100um were used for sampling micro-and-macro-zooplankton respectively. Samples were fixed in the field with 5% formalin & glucose solution. Laboratory examination and counting proceeded under a binocular dissecting microscope after sub sampling procedures.

General remarks & Summary

There is a remarkable uniformity in species composition and community structure of zooplankton in all three lakes, with the cyclopoid copepods (and *T. neglectus* in particular) as the numerically superior group in the limnetic environment. Most of the zooplankters are eurytopic, occurring in almost the whole range of habitats in each of the three lakes. Diaptomid copepods cladocerans, rotiferans and aquatic insect larvae and the decapod prawn, though common to all three lakes contribute much smaller proportions to total zooplankton. Absence of daphnid cladocerans in Lake Kyoga and virtual absence of diaptomid copepods in Lake Albert are notable exceptions. Differences in lake morphmetry, limnological and biological characteristics may explain such community structure differences. Recent(preliminary) studies on trophic interactions between fish and zooplankton community in Lake Victoria have indicated preferential consumption of crustacean and other categories of zooplankton by both larval, juvenile and some adult fishes (personal observations). Reports in literature on the subject show fish predators as the chief architects of zooplankton community structure and species abundance patterns. Thus the observed differences across the three lakes can be partly attributed to the impact of fish planktivory. All three lakes have rich pelagic, planktivorous fish communities e.g. *R. argentea* in Lakes Victoria and Kyoga and *Brycinus nurse* in Lake Albert.

Constraints

- In order to obtain an insight into aspects of energy flow between zooplankton and other trophic levels, it is necessary to estimate standing crop biomass in units of dry weight. Such determination requires the use of a sensitive (ca. 0.1ug) balance. Lack of this equipment is still a major constraint in current zooplankton research efforts.

- There is need for adequate funding to allow the more distant lakes Kyoga and Albert to be sampled more often in order to get more meaningful data sets of zooplankton and other displines for comparison with Lake Victoria and other water bodies in the region.

Future projections

Future work will continue the periodic monitoring activities so as to build up a time series data base needed for interpretation of corresponding fishery yield data. In addition dry weight data will be generated upon acquisition of suitable equipment. Production studies for the more important species e.g. *T. neglectus*, *Daphnia lumholtzi* etc will be embarked upon. Investigations into the zooplankton-fish interactions started on Lake Victoria will continue and possibly be extended to the other two lakes.

CHAPTER 3

3. THE FISHERIES RESEARCH PROGRAM

Background

During 1994, the major fish commodities produced in Uganda and the Constraints affecting fish production were identified and prioritized by NARO and the FIRI Research Program Planning and Review Committee. The research scientists on the program spent the year remoulding their studies to fit the prioritised commodities and constraints.

The Fishery Resources

Uganda has a high potential for fish production. The 1991 catch statistics show that the various water bodies in Uganda can produce upto 220,000 metric tonnes of fish annually. The relative importance is as follows: Lake Victoria (55%), Lake Kyoga (27%), Lake Albert and the Albert Nile (12%), Lakes Edward and George (6%). Although no statistics are available, small water bodies are important sources of fish for people around them and serve as reservoirs for endangered species. The most important fish species according to NARO's priority setting of 1994 (Table 1) were, in order of priority: Tilapia (Ngege), Nile perch (Mputa), *Rastrineobola argentea* (Mukene), *Bagrus docmac* (Semutundu), Haplochromis (Nkejje), *Clarias* (mud fish), *Hydrocynus* (Tiger fish), *Protopterus aethiopicus* (Lung fish), *Alestes* (Ngara), Molluscs (Bisonko), *Labeo victorianus* (Ningu) and *Barbus* (Kisinja).

Production Constraints

The NARO priority setting exercise and the FIRI Program Planning and Review Committee identified ten constraints which formed guidelines for the program research plans and activities during the year.

High priority constraints:

- effects of overfishing
- inadequate information on composition, abundance and distribution of the fish stocks,
- human interventions affecting aquatic resources and
- declining fish species diversity.

Medium priority constraints:

- open access policy to fisheries,
- inadequate information on the contribution of fish production to national economy,
- impact of exotics,

- inadequate knowledge on the structure and functioning of fishing communities,
- inadequate knowledge on the biology and ecology of the species and
- inadequate fishing technology.

These constraints included aspects of socio-economic research and these will be delt with in Chapter 6. Only aspects dealing with direct fisheries research are discussed in this chapter.

Overall Program Goal

The overall goal of the program is to generate knowledge required in formulation of development and management policies for enhancing increased and sustainable fish production.

Specific Objectives

- Determine the composition, abundance, distribution and population structure of fish stocks.
- Estimate fishing effort in the various water bodies to recommend optimum fishing effort.
- Study the biology and ecology of the major commercial species [food and feeding habits, fecundity, size at first maturity, sex ratios, breeding season, growth, mortality rates, length-weight relationships of the species and maps of areas important in fish survival].
- Determine fish species diversity, make an inventory of the species, identify those that are endangered and study the biology and ecology of rare species and suggest ways of improving stock of endangered species.
- Determine the impact of fish species introductions on fishery yield and on fish species diversity.
- Determine the impact of fishing gears and methods on fish stocks and fish production to recommend suitable gears and methods.
- Examine Uganda's fisheries resources management regulations and advise on how these can be improved.

Projects under the Fisheries Program

The objectives are examined under five projects:

- Lake Victoria Fisheries Research Project
- Lake Kyoga Fisheries Research Project

- Lake Albert and the Albert Nile Fisheries Research Project
- Lakes Edward and George Fisheries Research Project
- Research in the Fisheries of the Small Water Bodies. These were classified into five sub-projects:
  - Lake Wamala,
  - Nabugabo Lakes (Nabugabo, Manywa, Kayugi, Kayanja & Kitunga),
  - The Koki lakes (Kijanebalola, Kachera, Mburo and Nakivali),
  - The Kyoga minor lakes,
  - The small lakes of western Uganda,

- Studies of the Impact of Fishing Gears and Methods on Fish production continued to be regarded as a single project operating across the lakes.

Studies

Each objective forms a study under each project. The biology and ecology of each major commercial species also forms a study. The various projects under the program have a component of socio-economic studies. These are reported under the socio-economics section of the annual report.

Research Activities of the Fisheries Program

Most of the research activities during the year were concentrated on Lakes Victoria and Kyoga mainly due to availability of funding provided through the Lake Productivity Project and the EU Lake Victoria Fisheries Research Project and various collaborative efforts. Detailed activities of the projects are given in individual project write ups.

Achievements

Details of these are reported by individual projects and studies. Overall, the information collected during the year included:

- Data on composition, relative abundance, distribution, and biology of the major commercial species (Nile perch, Tilapiines and Mukene) and recommendations on the size at which these should be cropped.

- Observations on surviving endangered native species, factors that promote their survival, and recommendations on conservation of the species.

- Information on fishing gear selectivity and on the fishing methods used and recommendations on suitable types and sizes of nets for lakes Victoria, Kyoga and Nabugabo.

- At least two papers were published by scientists from the program on the above aspects. Six brochures were also produced by program personnel.

Major Constraints

The main constraint has been lack of funds for research activities especially on lakes Albert, Edward and George which do not have donor funding.

Future Plans

- Continue monitoring fishing effort, composition, abundance and distribution of the stocks;
- monitor population parameters of major commercial species to see how they respond to predation and human exploitation;
- make an inventory of and collect biological and ecological data on surviving species with emphasis on improving their stocks;
- package data on fishing gears and methods for all major water bodies in Uganda.
- examine the available fisheries management regulations and recommend on how these can be improved.

3.1. Lake Victoria Fisheries Research Project

Eight studies were conducted under the Lake Victoria Fisheries Research Project, namely:-

- Composition, abundance and distribution of the fish stocks,
- Fishing effort and optimal levels of exploitation,
- The impact of exotic species,
- Nile perch studies,
- Tilapia Studies,
- Mukene (*Rastrineobola argentea*) Studies,
- Study of surviving haplochromine cichlids, and
- Study of surviving non-cichlids.

Activities

During the period January to December 1994 the project personnel participated in fisheries resources evaluation surveys involving trawling using MV IBIS, gillnetting and catch/effort studies, training, attending of workshops and meetings, analysis of data and compilation of reports.

Fisheries Resources Evaluation Surveys

IBIS Cruises

A total of 10 cruises were made to Lake Victoria on a monthly basis. The lake had been divided in three zones for sampling purposes. Zone I covers the area between the Tanzanian / Uganda and Bukakata, Zone II between Bukakata and Kiyindi and Zone III between Kiyindi and the Kenya / Uganda border. One-hour trawls were made using 25.4 mm mesh codend nets in selected transects covering waters 4 - 50 M deep. Two cruises were made to Zone I, while four cruises were made to each of Zone II and Zone III. Each cruise lasted 4 to 6 nights. The information collected includes:- fish species composition, distribution and abundance; population structure; feeding habits; size at first maturity; sex ratios; food and feeding habits of major fish species and limnological parameters. The results of individual studies are given in the section 3.7.

Gill netting and Catch - Effort Studies

A total of seven trips (3 to Bukakata/Kalangala/Masaka/Mpigi and 4 to Entebbe) were made to Lake Victoria (Uganda) during 1994 to conduct experimental gill netting and catch/effort studies. Fleets of gill nets ranging from 50.8 mm to 203.2 mm mesh sizes were used for experimental fishing and fishermen's catches were recorded and analyzed at the landings. Information obtained included fish species composition, catch rates and size structure of the fish caught and landed.

Achievements

Results obtained and recommendations made are given under study results.

3.2. Lake Kyoga Fisheries Research Project

Background

Lake Kyoga is the second most productive lake in Uganda contributing about 30% of total national fishery yield. The lake also has three highest priority species, Nile perch, Nile tilapia and Mukene. The lake has suffered loss of fish species diversity due to introduction of the predatory Nile perch. Stocks of some fish species that had previously been severely reduced by Nile perch predation have recently shown signs of recovery.

Studies under the project

Studies under this project are generally similar to those of Lake Victoria and include:

- stimation of the composition, relative abundance and
- distribution of the fish stocks,
- studying the biology and ecology of the major commercial species,
- monitoring the impact of introduced species on fish species diversity and fishery

yield,
- determining current fish species diversity, studying the biology and ecology of endangered species and
- examining the factors that facilitate resurgence of native species.

Research activities

The activities of the project during 1994 were made possible through the funds provided under ARTP, Lake Productivity Project and collaborative efforts with the New England Aquarium, Boston and the University of Florida, USA. Under these arrangements, the project was able to maintain one assistant at Bukungu landing on a monthly basis to collect some basic fisheries and biological data on the lake on a monthly basis. A fisheries research team was also able to visit the lake four times on a quarterly basis.

Data was collected on the composition and relative abundance especially of the three major commercial fish species, Nile perch, Nile tilapia and Mukene, the impact of exotic fish species on fish species diversity and fish production, resurgence of some native species, factors which seem to be facilitating the resurgence especially the role of refugia in fish survival. Some results and recommendations are given in section 3.7.

Main Constraints

Main constraint has been lack of funds. The lake also requires a larger boat which can be used for surveys.

Future plans

To follow up the development of the Mukene Fishery which has started to expand on the lake and its impact on other fisheries.

3.3. Research on Lake Albert and the Albert Nile

Background

Lake Albert is the third most productive lakein Uganda contributing about 12% to total national fish production. It is the source of Nile perch and Nile tilapia which which were introduced and support a lucrative fishery in lakes Victoria and Kyoga. It is the only lake which still has a well pronounced multi-species fishery in the country with about 12 fish species occuring regularly among commercial catches. Due to poor infrastructure to the lake, most of the fish landed is marketed either in Zaire or West Nile.

Research Activities

Due to being far away from FIRI laboratory in Jinja, Lake Albert is one of the least studied lakes in Uganda. Recent efforts have involved collection of comparative data on the biology and ecology of Nile perch and Nile tilapia in respect to the biology and ecology of these species in their new habitats of lakes Victoria, Kyoga and Nabugabo. Some of the result pertaining to this aspect are given section 3.7. Very limited data been collected on other aspects of the fishery.

Constraints

The main constraint has been lack of funds for field operations.

Future plans

During 1995, efforts will be made to collect data on other aspect the fishery beyond those mentioned above.

3.4. Lakes Edward, George and Kazinga channel Fisheries Research Project

Lakes Edward, George and Kazinga Channel are a major source of fish for the heavily populated region of Western Uganda and for export to Zaire. One of them, Lake George, was the most productive lake in Uganda during the 1960s. However, fish production from these lakes decreased from 9950 tonnes metric tonnes in 1970 to 5500 metric tonnes by 1989 apparently due to lack of good management strategies. The contribution of Nile tilapia, which had been the most important commercial species decreased from 80% of the catch in 1970 to 35% in 1989 and its average weight decreased from 0.60 kg to 0.45 kg during the same period. These changes could have been due to overfishing or changes in availability of food but data to elucidate on this is lacking. Periodic fish kills have also been reported on the lake. Although this may be due to periodic upwelling of anoxic bottom mad, it may also be caused by input of pollutants from the catchment area especially copper.

Planned Objectives

The plans of this project were primarily to examine the overall program goal and specific objectives and how they apply to Lakes Edward, George and the Kazinga Channel.

Activities

Due to lack of funds, there were no research trips to these lakes but phytoplankton in water samples and stomach contents of Nile tilapia collected in 1993 were analysed to find out whether there was enough food available for the Nile tilapia.

Achievements

- Identified organisms in water samples and analysis food items ingested by Nile tilapia.
- A paper on the food and feeding habits of Nile tilapia from Lakes Edward, George and Kazinga Channel is being prepared and is summarised in section 3.7.

Constraints

The main constraint has been lack of funds to make expedition to the lake.

Future Plans

The program hopes to re-allocate funds to facilitate at least two expeditions to the lake during 1995.

3.5. Research in the Fisheries of the Small Water Bodies, Rivers and Swamps

Background

Small water bodies river and swamps comprise the other fisheries other than those described above. The fisheries of these water bodies are important especially in local production but little is known about it. Most of these small water bodies lie in the drainage basins of the large lakes and represent ecological zones of complimentary importance to the fisheries of the large lakes.
The program planned to examine the following categories:

- Lake Wamala,
- Nabugabo Lakes (Nabugabo, Manywa, Kayugi, Kayanja & Kitunga),
- The Koki lakes (Kijanebolola, Kachera, Mburo and Nakuvali) and associated smaller water bodies and swamps up to the western shores of Lake Victoria,
- The Kyoga Minor Lakes,
- The small lakes of Western Uganda,

3.5.1. Lake Wamala

Background

Lake Wamala is about 180 km^2 and is located in Mityana sub-District. The lake was stocked with the tilapiine species, mainly *Oreochromis niloticus* in 1956 and was opened to commercial fishing during 1960. The lake provided a very profitable commercial fishery throughout the 1960s, producing an average of 4000 metric tons of fish annually during the period 1960/76. However, during the early 1970s the catches started to decline from about 8 kg per net night in 1966 to less than 1 kg per net night in 1975. Recent observation show

that the fish in the lake are stunted.

Research activities

Fisheries resources surveys have been conducted on the lake since 1975. These revealed that the decline in catches was a result of increased fishing effort starting from about 1967. During 1981/86 the area experienced a severe dry period and apparently because of civil unrest fishing activities declined. The severe and long dry season resulted in the shrinking of the lake.

During the 1988/92 surveys stunting of the fish was evident and studies to establish the causes were initiated. These could however not continue due to lack of funds.

Constraints

As indicated above, the main constraint has been lack of funds for field operations.

Future plans

Some surveys are planned to establish the possible causes of stunting.

3.5.2. Nabugabo Lakes

Background

Nabugabo lakes include; Lake Nabugabo, Manywa, Kayugi, Kayanja & Kitunda. These satellite lakes are located along the western shore of Lake Victoria and are believed to harbour remnants of the Lake Victoria fish fauna. Lake Nabugabo has introductions similar to those that were made to Lakes Victoria and Kyoga and currently has a similar fish fauna. No introductions have been made to the other four nearby lakes.

Study objectives

- To examine the impact of introduced species to the Nabugabo fish fauna.
- To make an inventory of fish species diversity in the other four lakes for remnants of fish species which have been depleted from lakes Victoria, Kyoga and Nabugabo.

Activities

Work on the above lake Nabugabo, Manywa, Kayugi and Kayanja started in 1992 and some information of the fauna has been published in international journals. No visits have been made to Lake Kitunda. Two trips were made to the lakes during 1994.

Future plans

During 1995, we hope to extend the work to Lake Kitunga and to compare data from these lakes with the Lake Victoria shoreline near them.

3.5.3. The Koki Lake

Background

The Koki lakes; Kijanebalola, Kachera, Mburo, Nakivali and about 14 other smaller lakes are located in South-Western Uganda. They are all shallow 3 m to 4 m deep and are all connected by swamps.

These are probably now the single largest source of *Protopterus aethiopicus*, haplochromines, and *Oreochhromis esculentus* fishery in the country.

Study objectives

The objectives of the work on the lake were:

- to examine the fish production potential of the lakes.
- to carry out an inventory of the fish fauna and determine fish species diversity.
- to determine the biology, ecology and population parameters of the most important commercial species.
- to determine the impact of human exploitation on the fish stocks, and specifically the impact of fishing gears and methods.

Activities

One exploratory trip was made to lakes Kijanebalola, Kachera and Mburo in 1994. The data has been analyzed and is being written up.

Future Plans

Trips are planned to collect more data from the lake during 1995. However, funding remains a major constraint.

3.5.4. The Kyoga Minor Lakes

Background

Like the Nabugabo lakes, the Kyoga minor lakes besides being of economic value are believed to harbour remnants of fish species which stocks are threatened by the presence of Nile perch in lakes Victoria and Kyoga.

Objective

The objective of research on these lakes is to make an inventory of the species to facilitate their conservation and management.

Activities

No research activities were undertaken on the lake primarily due to lack of funds.

Future plans

Plans are under way to visit some of the lakes during 1995 using funds of collaborators.

3.5.5. The small lakes of western Uganda

Data was collected from these lakes during 1994 and there is no hope for funds to cover during 1995.

3.6. Packaging of Fishing Gear Technologies for Formulation of Regulatory Laws

Background

Most fisheries resources on Uganda consist of several species which mature at different sizes but living in the same waters. Fishermen employ different fishing gears and methods to harvest the fish. Some of these gear types and methods although they catch mature individuals of some species, they also catch immature individuals of other species found in the same water. The existing regulations on fishing gear and methods are inadequate and inapplicable to all water bodies. Besides, the fisheries of most lakes have changed and the regulations contained in the Fish and Crocodiles act are no longer applicable for most lakes.

The main goal of this project is to generate knowledge on suitable fishing gear types, sizes and methods for optimum and sustainable exploitation of Uganda's fishery resources and to advise on how the regulations could be improved.

Specific objectives

- To carry out experimental fishing trials on Lake Victoria using various gears, gears sizes and fishing methods analyze commercial catches from various fishing gears, gear sizes and fishing methods on other water bodies, carry out socio-economics interviews for fishermen, review existing data and literature and package preliminary information on fishing gear technology.

- Examine the existing fisheries management legislations and recommend on how these could be improved.

- Disseminate the information to Extension workers, policy makers and the public.

Activities

- Preparation of socio-economics questionnaires, testing and interviews for Lakes Edward, George and Kazinga Channel were carried out.
- Completion of experimental fishing trials using castnets active gillnet fishing and long line fishing on Lake Victoria were completed.
- Reviewed existing literature and data related to fishing technologies on Uganda waters.
- Analysis of data.
- Preparation of paper for publication, brochures and recommendations on exploitation of the fisheries of Lake Victoria, Kyoga and Nabugabo and dissemination to some of the Fisheries Extension staff.

Future plans

- Complete collection of data on socio-economics and fisheries.
- Data coding and analysis
- Identification of legal local consultant to assist in examination of the existing fisheries regulatory laws
- Conduct workshops for District Fisheries Officers, representatives of fishing and processing communities and fishermen at fishing landings
- Prepare final report and brochures containing recommendations

3.7. Results of Individual Studies

The reports of individual studies contains the results obtained during the year and specific recommendations for management of the resources. Some of the studies, especially those on the biology and ecology of fish species may cover more than one lake.

3.7.1. Composition, abundance and distribution of major commercial fish species in Lake Victoria.

By John Okaronon

Background

Until the 1970s the fishery of Lake Victoria was multispecies dominated by the tilapiine and haplochromine cichlids, but with important subsidiary fisheries of more than 20 genera of non-cichlid fishes such as the cat fishes (*Bagrus docmac*, *Synodontis* sp and *Shilbe mystus* - Nzere), the mud fishes (*Clarias* spp), the lung fish (*Protopterus aethiopicus* - Mamba) and *Labeo victorianus* (Ningu). Stocks of most of these species declined and others disappeared following the introduction of three tilapiine species (*Oreochromis niloticus* - Nile tilapia, *Oreochromis leucostictus*, and *Tilapia zillii*) during the 1950s and the Nile perch (*Lates niloticus*) during the 1960s. The fishery then became dominated by the Nile perch and the Nile tilapia and only one native *Rastrineobola argentea* (Mukene). These changes were accompanied by rapid increases in fish yield.

Lake Victoria has also become an important source of fish not only for local consumption but also for export and a number of fish processing plants have been constructed along the shores of the lake. Subsequently, the fishing effort in the Ugandan sector of the lake increased from 3200 canoes in 1972 to 4500 in 1988 and 8000 by 1990. This increase in fishing effort and investment was made without clear knowledge of the magnitude and sustainability of the stocks.

There are indications that both the fishery yield and species diversity are declining. Despite the increase in effort, fishery yield from the lake decreased from 132,000 tonnes in 1989 to 120,000 in 1991. The 1991 catch was dominated by Nile perch (76.1%) and the Nile tilapia (20.9%), both of which were insignificant in the 1970s, the rest was composed of *Clarias* (1.3%), *B. docmac* (0.7%), Mukene (0.6%), and *Protopterus* (0.4%). Other species which used to form major fisheries have been reduced to negligible levels and actual stock sizes are not known.

The exact current stock sizes in the lake are unknown. The only stock assessment exercise was undertaken during the late 1970s before the above changes took place. The current stock assessment exercise is intended to generate information to guide management of the fishery. This includes estimating the current composition, abundance, population structure and distribution of the stocks.

Species composition

During the 1994 survey, 14 fish taxa (belonging to 11 genera) were recorded. Nile perch contributed about 90%, Nile tilapia 3.1%, *P. aethiopicus* 1.7%, *Synodontis afrofischeri* 0.8%, *B. docmac* 0.5%, and haplochromines only 0.4%. Others encountered in very small quantities included *O. variabilis*, *O. leucostictus*, *Tilapia zillii*, *S. victoriae*, *Barbus* spp, *Mormyrus kannume* and *R. argentea*. During the 1969/71 survey, haplochromines contributed 83%, *B. docmac* 4.2%, *Clarias* sp 4.1, *O. esculentus* 3.8%, *P. aethiopicus*

2.8%, Nile tilapia 0.5%, *S. victoriae* 0.4% and Nile perch was less than 0.1%.

Distribution

Trawl surveys of 1994 show that the bulk of the fish (60%) was in waters less than 30 metres deep. Nile perch and haplochromines were encountered in all the areas sampled while Nile tilapia and other tilapiines were restricted to waters less than 30 m deep. The highest diversity of about 11 fish taxa were recorded in Napoleon Gulf. More than 20 genera (excluding the haplochromines) were recorded during the 1969/71 survey. Notably absent during 1994 are; *Xenoclarias*, *L. victorianus*, *S. mystus*, *Alestes jacksoni*, *Mastacembelus frenatus* and *Gnathonemus longibarbis*. However, experimental fishing in shallow inshore areas on the lake has revealed that some of the species notably A. jacksoni are confined to inshore areas.

Catch rates

The mean trawl catch rates ranged from almost zero in Buvuma (Zone III) and Damba Channel (Zone II) to about 1 metric tonne\hr in MacDonald Bay (Zone III) and Kagegi Gulf (Zone I). The mean catch rate in waters 4 - 29 m was 160 kg\hr. During the 1969/71 survey the mean catches in waters less than 30 m deep was 797 kg\hr. Mean catch rates varies with season. For instance mean catch rates in Zone III varied from 196 kg\hr in June and August to about 45 kg\hr in November. In the gill nets, the average catch per canoe (with about 80 nets of mixed mesh sizes) operating in the Entebbe waters was 25 kg of fish per net per day during 1994. The catch was dominated by Nile perch.

Fish population Structure

Nile perch from the 25.4 mm mesh codend trawl ranged from 9 cm to 148 cm total length most of them being within 35-60 cm length.

3.7.2. Impact of Nile perch (Lates niloticus) on fishery yield and fish species diversity in lakes Victoria, Kyoga and Nabugabo.

By Ogutu-Ohwayo, R.

Background

Nile perch (Mputa), *Lates niloticus* L. was introduced into Lakes Victoria and Kyoga from Lake Albert to increase fish production of these lakes by feeding on and converting the small sized haplochromines (Nkejje) which were abundant in these lakes into a larger table fish. It was, however, feared that Nile perch would prey on and deplete stocks of the native fishes and affect fish species diversity. Nile perch became well established and is currently among the three most important commercial species. It is presently the most important export fish commodity from Uganda. Considerable changes have taken place in fishery yield, the number of species in the lakes and in life history characteristics of the Nile perch itself since the predator got established in Lakes Victoria and Kyoga.

Fishery yield

After establishment of the Nile perch, fishery yield in lakes Victoria and Kyoga increased five to eight times. Total yield in the Ugandan region of Lake Victoria increased from 17,000 tonnes in 1981 to 132,000 tonnes by 1989 due to increase in contribution of Nile perch from 14,000 tonnes in 1983 to 101,000 tonnes in 1989. Similarly total yield in Lake Kyoga increased from 18,000 tonnes in 1964 to 167,000 tonnes in 1978 due the rise in the contribution of Nile perch from about 700 tonnes to 71,000 tonnes. However, the yield of Nile perch in Lake Kyoga later decreased to 15,000 tonnes by 1989 suggesting that Nile perch may not sustain the high yields realized soon after its establishment in the new habitats. This decline has been attributed to heavy fishing pressure use of destructive fishing gears and methods especially beach seines. On Lake Kyoga, seining is rampant to date even in open waters.

Fish species diversity

Before establishment of the Nile perch, up to 14 fish species occurred in the commercial catches. After its establishment, the number of exploited fish species decreased to three. Nile perch, Nile tilapia and one native species; *Rastrineobola argentea* (Mukene). Although the original decline was due to overfishing, that after establishment of Nile perch was mainly due to predation by the Nile perch. Since 1991 stocks of haplochromines and other native species have started to increase in Lake Kyoga. This seems to be due to the reduction in predation pressure as a result of over-fishing of Nile perch and the increase in cover from predation provided by the expansion of the water hyacinth.

Food of Nile perch

Before Nile perch became well established in lakes Victoria and Kyoga, haplochromines and small mormyrids (Kasulu) were the main food in all but the smallest sizes of the predator. As populations of Nile perch increased, stocks of haplochromines and other native species declined. Thereafter prawns, *Caridina nilotica* and dragonfly nymphs became the dominant prey of juvenile Nile perch while larger Nile perch ate Mukene, Nile tilapia and its own young. The average sizes and numbers of prey eaten have also changed. Following increases in haplochromine stocks in Lake Kyoga since 1991, haplochromines have again become important food of Nile perch in the lake. Similar increases in haplochromine stocks have started to occur in inshore areas of Lake Victoria.

Condition factor - Fatness

Nile perch in the new habitats were initially heavier and fatter than in native habitats due to abundance, at that time, of vulnerable haplochromine prey. After haplochromines had been depleted, the average weight of the fish decreased and they are now lighter than even in their original habitat. Reduction in Nile perch prey through human over - exploitation can depress the condition of the Nile perch to levels that would affect the health of its stocks and should be avoided.

Reproduction

Male Nile perch mature at 50 - 55 cm total length and females at 90 - 100 cm. The species has a very high reproductive potential; females produce 3 to 18 million eggs depending on size. There are more males than females in Lakes Victoria and Kyoga than was the case when food was abundant. Although reproductive potential of the Nile perch does not seem threatened by changes in prey supply due to the very large numbers of eggs produced, the male biased sex ratio might have some effects on the stocks.

Future of Nile perch fishery

The decline in Nile perch yield in Lake Kyoga, the reduction in the prey supply in the new habitats, the decrease in average weight of the Nile perch and the male biased population suggest that Nile perch may not sustain the very high yields realised soon after its establishment in Lakes Victoria and Kyoga. This situation is compounded by the very high fishing pressure on the species due to the very high demand for fish by the increasing human population and the export oriented fish processing plants.

Management

For the Nile perch fishery to remain sustainable, it will be necessary to: eliminate destructive fishing gears and methods, control fishing effort and avoid depleting Nile perch prey.

3.7.3. Tilapia fisheries

By Balirwa, J.S.

Tilapia is the common English name for the most common fish in Uganda variously known as Ngege, Mpongo, Mbiru, Zogoro, Sato, Kaishata, Mahere, Oro, Apok, Tuf, Kibat, etc in various parts of Uganda and East Africa. The names refer to several varieties of tilapia by the scientific names: *Oreochromis niloticus, O. variabilis, O. esculentus, O. leucostictus, S. galilaeus and Tilapia zillii*. Previously, before 1955, Lakes Victoria and Kyoga contained only *O. variabilis* and *O. esculentus*. The other tilapia which occur in the Nile system lakes were stocked in large numbers in the two lakes as a form of fisheries management. Nile tilapia is now well established in these two lakes where it is the basis of the commercial fisheries.

NARO recognises the importance of tilapia to food security and has ranked the Nile tilapia (*Oreochromis niloticus*) as the most important food commodity from water bodies in Uganda. For all practical purposes, tilapia are the single most important taxon of capture fisheries from small water bodies and shallow zones (1-3m) of the larger lakes. As tilapia are basically shallow water species, studies were concentrated in the inshore habitats of Lake Victoria where wetland buffer degradation is the most important constraint.

Methodology

New methods which quantitatively sample fish in shallow vegetation fringes of Lake Victoria were designed and successfully operated. Code-named "Block and Diagonal

Quantitative Fishing Experiments", results from the work undertaken give an indication of the importance of shallow habitats for fish populations. Moreover, comparisons can now be made regarding fish production from the habitats between 1960 and the present. Other information generated covered aspects of the biology and ecology of the species.

Species Composition

At least 23 taxa occur in the shallow wetland zone where tilapiines (mostly as Nile tilapia) are the most abundant. Abundance patterns are strongly correlated with vegetation type which also determines size- and sex-related habitat occupation by the Nile tilapia.

Distribution patterns

Apart from the influence of vegetation, depth and bottom substrates influence which taxa occur at what distances from the shoreline. This is also reflected in the apparent influence of wetland degradation on longitudinal distribution patterns by different species.

Seasonal patterns

One of the corner stones of fisheries management is the potential for the use of closed seasons to control effort and guarantee successful reproduction and subsequent recruitment to the fishable stocks. In Lake Victoria, the seasons of most significance to fish can be classified as: Dry season - December to March 15th; Main Rain/Wet Season - March 16th to end of June; Short dry season - July to September 15th and the Short Rain season - September 16th to end of November. These seasons are determined from long-term means which when compared to climatic data of the year show correspondence of periods of rain, number of days with rain per month, etc.

Results obtained during the year also show clearly that apart from the seasonal consequences of habitat use, seasonality plays an important role in both abundance patterns and geographical spread of sex ratios. For instance, whereas in the general population of Nile tilapia a 1:1 sex ratio is common, it changes with season and with vegetation type.

Temporal trends in tilapia fisheries

The areas of present investigations are similar to those for which estimates of fish production were made from 4.5" (114.3 mm) mesh size gill nets during 1960s when *O. variabilis* and *O. esculentus* were the dominant tilapiines from the lake. A recalculation of biomass per hectare shows that in the earlier period, one net was fishing 13.5ha and providing about 9kg.ha^{-1}.yr^{-1} of tilapia. By using the present quantitative techniques, it has been shown that the expected catch at present would give a production of 18kg.ha^{-1}.yr^{-1} of Nile tilapia. However, where the fishing effort was calculated at 0.074nets.ha^{-1} in 1960s, the effort estimated for 1994 in the same area was 13X greater i.e about 1net.ha^{-1}. This leaves the landed catch per canoe or per fisherman lower than in the past. What this suggests is that as in the past, from the recommended 5" mesh size gillnets, fishermen have reduced gear size to the more profitable 4" and 4.5" associated with the extensive use of cast nets, barrier nets of all sorts and water beating.

3.7.4. The Mukene (*Rastrineobola argentea*) Fishery of Lakes Victoria, Kyoga and Nabugabo

By Wandera S.B.

Background

Mukene (*Rastrineobola argentea*) occurs in Lakes Victoria, Kyoga and Nabugabo. It is currently the third most important commercial species in Uganda. It is second to Nile perch in Lake Victoria, and its fishery is developing fast in Lake Kyoga but is still not commercially exploited in Lake Nabugabo. Mukene is a cheap source of protein food for direct human consumption and is widely used in animal feeds. It is also an important food item for Nile perch and is the only native species which has persisted in those lakes to which Nile perch was introduced.

Food and feeding habits

Mukene feeds on tiny organisms; zooplankton and insect larvae mainly of chaoborids and chironimids. Most of the feeding takes place during day time. Zooplankton are eaten mainly during day time and insect larvae and pupae at night.

Life history

Mukene currently grows to a maximum length of 54 mm but used to attain a length of 65 mm before it was over-exploited. Peak breeding occurs twice a year in the months of August-September and December-January. Fish from these breeding peaks appear in the commercial fishery eight months later in April-May and August-September. Mukene matures at the age of ten months at an average length of 43 mm and are ready to breed just after one year. In areas with intensive fishing pressure, these broods are fished out just over one and half years.

Fishing methods

Mukene is fished by light attraction at night. Lighted kerosene pressure lamps are anchored floating on the lake surface. The fishes attracted to these lights are retrieved using a variety of methods:-

Lamps are slowly drawn from open waters towards the beach bringing with them fish attracted to the light. Near the beach a large beach seine is cast around the lamps, pulled ashore and the fish is retrieved.

A seine net is cast round an individual lamp and pulled towards an anchored canoe and the fish removed into a canoe. This is more efficient than the above method as no time is wasted in towing the lamps towards a beach.

A lighted lamp is hang in front of a stationary or slowly moving canoe and the fish are scooped using a hand-held scoop net with a long handle. The method is common on Lake

Kyoga and the Western region of Lake Victoria.

A large lift net is lowered under water around the lamps and the fish are lifted in the net.

Fishing operations are concentrated in shallower inshore areas and near islands. The vast open waters of Lake Victoria still remain unexploited mainly due to the small size of boats used which cannot withstand the rough waters of the open lake. In most places fishing is restricted to moonless nights.

Processing

Mukene is rarely eaten fresh. The catch is sundried usually on rocks and packed in sacks for sale. Because processing relies on sunshine, best quality and big catches are realized in the dry months of June to August and December to February. During rainy months poorer quality Mukene is normally available on the market. Total catches during these months also tend to be low because the rains interfere with fishing operations. While some Mukene is eaten directly by humans, the bulk is used in manufacture of animal feeds. Some is exported.

Parasites of Mukene

The fish is parasitised by a tapeworm *Ligula intestinalis* which occurs in the pleural cavity of the fish. The parasite occurs in less than 1% of the fish and is common inshore. The parasite destroys gonads of infected fish and affect reproduction. There is no evidence that the parasite is harmful to humans. Parasites move out of the fish as soon as it is landed. It is however advisable that the fish is cooked thoroughly before consumption.

The future of the fishery

Because Mukene is resilient to predation by the Nile perch which is partly responsible for the disappearance of many native species from Lakes Victoria and Kyoga, its fishery has potential for future development and exploitation. Presently only a small area of Lake Victoria is under exploitation. This fishery has the potential to expand if larger and safer boats which can operate offshore can be developed. This would also reduce pressure on the inshore areas currently under heavy exploitation.

Management of the fishery

The combined effect of predation and human exploitation can deplete Mukene stocks if the fishery is not properly managed.

- The 5 mm mesh size nets catch large quantities of immature Mukene during the months of April to May and September when new cohorts are released into the fishery. It would be advantageous if fishing for Mukene could be prohibited during these months.

- The Lampara net operated offshore captures mainly Mukene while beach seines also catch high proportions of juvenile Nile perch and Nile tilapia. Fishing for Mukene

should therefore be done using lampara type nets operated offshore.

- The minimum mesh size limit for Mukene should have been 10 mm but since all fishermen have shifted to 5 mm mesh nets, the minimum mesh size should not be allowed to drop below 5 mm pending further investigations.

3.7.5. Conservation of endangered native fishes in lakes Victoria, Kyoga and Nabugabo: the role of refugia in fish survival

By Olowo, J.P. & G. Namulemo

Background

Lakes Victoria, Kyoga and Nabugabo supported a high diversity of fish species. The non-cichlids alone numbered about 50. Of these, about 10 were commercially important. These included *Bagrus docmac* (Semutundu), *Clarias gariepinus* (Male), *Protopterus aethiopicus* (Mamba), *Labeo victorianus* (Ningu), *Synodontis afrofischeri* (Nkolongo), *Barbus altianalis* (Kisinja), *Mormyrus kannume* (Kasulubana), and *Schilbe intermedius* (Nzere). These species were cherished by the local population. They were an important source of protein and income. At first, some of them began to decline due to bad fishing methods. Later, Nile perch predation drastically reduced their populations so that most of them became scarce or absent. The people have lost variety and cheap sources of protein. The Nile perch is now export oriented and expensive. The ecological consequences of the loss in diversity is yet to be assessed.
This study is intended to provide an inventory of endangered species that still survive in these lakes and to generate knowledge on their biology and ecology and on threats to their survival so as to recommend methods for conserving and improving their stocks.

Species that are still persisting

Current survey has shown that the following species still survive in localised habitats within these lakes: *B. docmac, P. aethiopicus, C. gariepinus, Clarias liocephalus, S. afrofischeri, M. kannume, Alestes jacksonii* (Nsoga), *Garra johnstonii (Lake Victoria only), Gnathonemus victoriae, G. longibarbis, Xenoclarias* sp., *L. victorianus, B. altianalis, S. intermedius* and *Afromastacembelus frenatus*.

Threats to survival of species

The following have been identified as the major threats to survival of the species:

- Over-fishing. This destabilises fish populations by reducing proportions of reproductive individuals and also exposes some species to increased predation.

- Indiscriminate use of destructive fishing gears and methods. This leads to destruction of spawning and nursery grounds and to the depletion of spawning adults. The trapping of spawning individuals led to the collapse of the *Labeo* fishery even before

the Nile perch became established.

- Predation by the Nile perch. This causes depletion of individuals of a species and forces some species to seek new and often less suitable habitats to reside is.

- Competetion with introduced species for various resources may result in reduced fitness for the poorer competitors. Reduced fitness results in poor survival and consequently in reduction of a population.

- Destruction of habitats that provide refuge from predation especially: Aquatic vegetation and Rocky outcrops within and along the lakes will deprive the species of their protection from the Nile perch. The species so exposed easily fall prey to the predatory Nile perch if they dont possess effective alternative mechanisms for predator avoidance.

- Failure to provide bypass routes (for fishes which migrate up rivers to spawn) during the construction of impoundments such as dams affects the reproduction of such fishes.

- Pollution renders the water environment unsuitable for fish for example it can lead to depletion of dissolved oxygen which leads to fish kills.

Factors facilitating survival

The following have been identified as the major factors facilitating survival of the species:

- Some species eg. *B. docmac and M. kannume* survive by hiding among rocks or aquatic vegetation. These areas provide cover that protect especially small sized species and juveniles of the larger ones from predation by the Nile perch.

- Species that are tolerant to low oxygen conditions eg. *P. aethiopicus* survive by living in marginal wetlands where Nile perch cannot survive.

- Species such as *A. jacksonii* and 'Mukene' survive by migrating either horizontally or vertically to areas where Nile perch may not be very active at specific times.

- Some species eg. *S. afrofisheri* and *S. intermedius* have protective spines which make it difficult for a predator that swallows its food, such as the Nile perch, to effectively attack them.

- Other species grow to a large size which renders them safe from predation by the Nile perch e.g. *C. gariepinus, B. docmac, P, aethiopicus* and *B. altianalis*.

- Some species have shifted to swamps e.g. *Ctenopoma muriei, Barbus neumayeri*, while others are now more common in the rivers e.g. *B. altianalis*.

Recommendations for conservation of some endangered species

In order to conserve and restore some of the endangered species it will be necessary to:

- Avoid clearing aquatic vegetation that serve as cover from predation.
- Avoid fishing in and destroying rocky outcrops
- Raise some species by fish farming (aquaculture) and stock them in dams.
- Designate some small lakes which still contain some of the endangered species into conservation areas.

3.7.6. Guidelines on types of fishing gears and methods for exploiting Nile perch, Tilapias and Mukene in Lakes Victoria, Kyoga and Nabugabo.

By J. Kamanyi, R. Ogutu-Ohwayo, & S.B. Wandera

Background

Collapse of important commercial fisheries on most of the lakes in Uganda were caused by introduction and indiscriminate use of certain fishing gears and methods without having sufficient means of controlling them. Lakes Victoria and Kyoga are currently the most productive lakes contributing over 80% to Uganda's fish production. The three highest priority species in Uganda; Nile perch (Mputa), Tilapia (Ngege) and *Rastrineobola argentea* (Mukene) are found in these lakes. Nile perch and Nile tilapia are mainly exploited using gill nets but seine nets, trawl nets, cast nets, hooks and basket traps are also used. Mukene is exploited by light attraction and seining or scooping.

Size at first maturity

In fisheries management, the size limit of fish that should be caught is set at the size at first maturity i.e. the size at which 50% of the fish are mature. This allows 50% of the fish to breed before they are caught. The size at first maturity of Nile Tilapia in Lakes Victoria and Kyoga is 23 cm total length for males and 25 cm for females and all fish are mature by 29 cm. The size at first maturity for Nile perch is 50-55 cm total length for males and 90-100 cm for females. The size at first maturity for Mukene is 42 mm standard length and by 45 mm all fish are mature.

Trawl and seines nets

Seines and trawl nets are operated as dragged gears. The dragging of these gears on the lake bottom especially near the margins of the lakes where tilapiines breed, destroys tilapia nests and disrupts courtship on breeding grounds of the tilapiines. These gears are also not very selective. They can catch smaller fish than would normally be retained due to blocking of the meshes by larger fish. Trawls with codends of mesh sizes less than 5" catch large

proportions of immature Nile perch and Nile tilapia.

Hooks

Hooks are mainly targeted at large Nile perch and although not much data on their selectivity characteristics are available, their impacts on the fishery is negligible. However, live bait is normally required to catch Nile perch. These are normally obtained using seines and small mesh size gill nets which are destructive to fish stocks.

Cast nets

The cast nets consist of a mixture of mesh sizes ranging from 3" to 8". They mainly catch tilapias by entanglement. Cast nets with mesh sizes of less than 4" catch high proportions of immature Tilapia. Cast nets when operated in shallow inshore areas interfere with breeding of tilapias.

Basket traps

Basket traps are widely used within vegetation areas along the lake margins and mainly target Tilapia. These are also the areas inhabited by young Tilapia. Traps with small meshes take large tolls of juvenile tilapia.

The impact of gill nets

Gill nets are the main fishing gears used in exploiting Nile perch and Tilapia. In lakes Victoria and Kyoga gill nets of less than 5" catch large numbers of immature tilapia. Therefore, the minimum gill net mesh size limit in respect to Nile tilapia should be 5". The minimum mesh size suggested for the Nile tilapia would crop immature Nile perch. However, biological and ecological considerations justify setting the minimum mesh at 5". Nile perch has a high reproductive potential. Females produce millions of eggs at each breeding. It is however a predator which when above 50 cm length becomes detrimental to the fishery by feeding on other commercially important fishes. Use of mesh sizes which crop Nile perch of more than 50 cm would be beneficial to the fishery by reducing predation pressure on the only two other commercially important fish species in these lakes. The size range of Nile perch coincides with the mesh size limit suggested for the Nile tilapia. The minimum mesh size of gill nets for lakes Victoria and Kyoga should be 5".

The impact of mosquito seine nets

Mukene in the Ugandan waters of Lake Victoria was initially exploited using a 10 mm mesh size beach seine. A 5 mm mesh seine operated either as a Lampara net or a scoop net operated offshore was introduced around 1989. While the 10 mm seine cropped mostly mature individuals, the 5 mm net captures a larger proportion of immature Mukene especially during the period when new cohorts are recruited into the fishery. The Lampara net operated offshore captures mainly Mukene with negligible quantities of Nile perch and Nile tilapia. Beach seine catches are composed of high proportions of juvenile Nile perch and Nile tilapia as bye-catch and are detrimental to the fishery of Nile perch and Tilapia when operated inshore. Fishing for Mukene should, therefore, be done using Lampara type lift net operated offshore. The minimum mesh size limit of seine net for Mukene on Lakes Victoria and

Kyoga should have been 10 mm but since virtually all fishermen have already shifted to the 5 mm net, the minimum mesh size limit for Mukene should not be allowed to drop below the current 5 mm mesh pending further investigations. This should be fished using Lampara net operated offshore.

A paper (co-authored) was prepared on "Fishing gear selectivity for Nile perch, Nile tilapia and Mukene" on Lakes Victoria, Kyoga and Nabugabo.

3.7.7. Food and feeding habits of *Oreochromis niloticus* of lakes edward, george and kazinga channel.

J. Kamanyi, Olet-Ogwang, E. Twongo

Background

Lake Edward is joined to Lake George through the Kazinga Channel. The phytoplankton and fisheries of this water system are more or less similar. *Oreochromis niloticus* (Nile tilapia - Ngege) -34% ranks second to *Bagrus docmac* (Semutundu) - 42% in commercial catches.

The water system contains phytoplanktons which form the major food for the Nile tilapia. However, since early 1970s the size of Nile tilapia and contribution in commercial catches has been on the decline. It was suspected that, probably the food among other factors could be limiting.

Analysis of water samples (phytoplankton count) and food items using point-method showed the following:-

Water samples: Phytoplankton encountered in order of importance were the Blue green algae dominated by *Mycrocystic, Planktolyngbya, Anabaenopsis, Anabaena, Lyngbyao* spp; Diatoms mainly *Melosira, Nitzchia, Naviciula, Surinella* spp. Of less importance were the Green algae mainly *Pediastrum* and *Scenedesmus* spp.

Stomach content analysis

Of the Phytoplankton; Blue green algae contributed 49%, Diatoms 34% and Green algae 17%. Table 1 shows the distribution of phytoplankton in stomach contents of Nile tilapia from different water bodies.

Other items found in the stomachs but of less importance were in order to magnitude Detritus material, sand grains high plant material, Rotifers unidentified insect remains chironomids, Copepods and animals remains.

Conclusion

The quantitative and qualitative changes that have taken place in Nile tilapia fishery are not due to lack of food but to other factors that need investigation. The Phytoplanktons which form the major food for the species are still in plenty and are consumed.

Table 1. Percentage occurrence of different phytoplankton in stomach contents of Nile tilapia from Lakes Edward George and Kazinga Channel.

Phytoplankton	Water body		
	L. Edward	L. George	Kazinga Channel
Diatoms	48%	24%	24%
Blue green algae	34%	60%	60%
Green algae	18%	16%	16%

CHAPTER 4

4. AQUACULTURE PROGRAMME

Background

Aquaculture Program is just one year old at Kajjansi. Fisheries Research Station Kajjansi started operating as a research station under a Fisheries Research Institute (FIRI) in January 1994 after its absorption by National Agriculture Research Organisation (NARO). There was only one on-going research project equal Captive Breeding and equally funded by World Bank and whose main objective was to transfer fish production technologies to farmers through extension staff.

After the absorption by the NARO there was need to prioritise the production constraints in order to formulate new related research projects to form an aquaculture programme. The production constraints were identified and prioritised as follows:-

Aquaculture Production Constraints

High Priority

- Lack of suitable feed formulation
- Inadequate technology for siting, designing and pond constraints
- Stunting
- Inadequate technology for fish production
- Low productivity
- Insufficient knowledge of economic feasibility
- Insufficient knowledge of pests, parasites and diseases
- Declining fish species diversity

Medium priority

- Limited aquaculture species and technology
- Water quality characteristics

Overall program Goal

The program goal was production of adequate fish food for human and animal protein requirements. And the formulated projects came out as:-

- Feed Formulation
- Fish Stunting
- Captive Breeding
- Pond Productivity
- Social Economics

Program Commodities:

Three species *Oreochronus niloticus, Tilapia zilli* and *Cyprinus carpio* (Mirror carp) have been the main fish species for production of fish fry. Predatory species like *Bagrus* and *Clarias* have been used in population control at the station.

Program Constraints

Inadequate staffing

Although the office of the Director General advised FIRI to have an internal institutional arrangement to transfer technical staff at Kajjansi this has not been achieved yet. Prioritasation of projects and studies was considered necessary in the face of inadequate staffing and funding. Noted also was need to encourage collaborative research (e.g with Makerere) which could cover certain aspects of aquaculture with minimum costs.

Inadequate Project Funding

The main source of funding has been the HARE Project under World Bank. The project ends in 1995. Revenue generation especially from sale of fry, eggs, ornamental fish, cray fish etc could partly sustain Kajjansi. But source of funding was possible if some attractive research projects especially **Integrated Fish Farming Projects** were formulated for sale to certain donnors.

Lack of Laboratory Equipment:

The laboratories lack equipment necessary for;

- Biochemical analyses in feed formulation
- Incubators for fry production.

It was important to note that some equipment that FIRI received under ADP which equipment was specifically for aquaculture still lie idle at FIRI Jinja. An attempt to get these equipments failed. This information was relayed to DDG when he visited Kajjansi on Monitoring Team (MEPU).

4.1. Captive Breeding Project:

Project overall objective: To transfer fish production technologies through extension workers to farmers.

Specific Objectives

- Rehabilitation of the breeding pounds at Kajjansi.
- Production and distribution of fish to farmers.
- Fry production for research.
- Training of extension staff and farmers in fish fry production technologies.
- Generate knowledge for extension staff and fish farmers.

Project Outputs

- Suitable breeding ponds
- Suitable species
- Revenue from sale of fry and other fish species
- Handbook

Captive Breeding Technologies & Achievements

- Forty ponds (33,000 square meter) were rehabilitated these ponds are now suitable for a number of experiments like feeding, breeding and growth studies.
- Collection of broodstocks from the wild. About 6000 *O. niloticus*, 700 *O. esculentus*, 80 *Bagrus* have been collected from the wild. 2000 Mirror carps have been grown to maturity from fingerlings.
- Over 55,000 Fish Fry have been distributed. Total revenue (fry sale) stands at 700,000/=.

- Training workshops were held. These involved 140 contact farmers selected from 14 districts, plus extension staff (DFO) from 14 districts.

- Aquaculture Brochure was compiled. After printing this was circulated to extension staff and farmers during workshops.

- A number of agricultural shows attended with full exhibitions. Attended FIRI open day and Presidential Forum on Science and Technology in Africa.

Comments on Captive Breeding Technologies

- It was noted that high cost of pond construction could be reduced by use of cheaper materials e.g use of bamboo for inlets/outlets instead of culverts and cement construction. The expensive pond maintenance was possible if the ponds could generate revenue from sale of fish fry, cray fish and ornamental fishes.

- Induced breeding using pituitary extracts was necessary to stimulate breeding of some species of fish like Bagus, Barbus, etc which do not breed in ponds. This activity was limited by personnel and funding. On farmers preference of mirror carp to Tilapia diagnostic survey should have been carried out by research on to establish fish farmers demand for fry before production commenced at Kajjansi. Much effort was initially concentrated on tilapia fry production which farmers could not take up. It was noted however that the shift from tilapia to mirror carp was sudden.

- Fry distribution from Kajjansi was still an expensive activity for farmers. Breeding at upcountry fry centres and at selected farmers could reduce expenses.

- Fisheries Research Station has not yet embarked on growing ornamental fish yet. Those fish encountered during routine pond sampling are sold to exporters.

- Fry distribution, organisation of workshops and seminars require timely coordination with and full participation of extension staff for mobilisation of farmers.

- The selection of 14 pilot districts in Uganda did not consider some districts which were worse off in fish production e.g Kapchorwa. The solution to such problems could involve establishment of a fry centre in the districts affected.

Gaps: Increased Fry Production Rate

This will necessitate the following:-

- More breeding ponds especially for mirror carp now on high demand.

- Careful study and improvement in Mirror carp breeding technologies.

- Feeding rates of species before and during spawning.

- Studies life cycles of try predators e.g cray fish.
- Construction of structures for pond protein against enemies.
- Devising an efficient system for fry distribution.
- More training workshops for extension staff and farmers.

Constraints

- Lack of trained personnel and limited number of hired labour force.
- Regular collection of tilapia from the wild.
- High expenses in fry delivery.
- Occasional bread down in pond structures.
- Heavy mortality on fry.

4.2. Feed Formulation:

Overall project objective was to formulate a suitable and cheap feed packages for fish farmers. The other objective was to carry out feed evaluation on a number of cultural fish species. The outputs from the study would be.

- Feed packages
- Knowledge to make feeds
- Revenue

Achievements

- Six food ingredients (maize bran, maize grain, brewery waste, 'Mukene', 'Nkejje' and lake flies have been purchased for studies.
- Processing of the food ingredients.
- Biochemical composition (protein, carbohydrate, fats, minerals) of the food ingredients have been analysed as:
- Combination ratios of protein, carbohydrate and vitamin premix have been worked out.

- Various combinations are being tried and preliminary observations are being made at experimental level.

Food	% Protein	% Carbohydrates	% Fat	Fe (ppm)	Ca (ppm)
Maize grain	9.8	75.7	4.8	4.1	15.3
Maize bran	9.6	73.0	3.4	3.8	15.7
Brewery waste	8.2	63.6	0.8	17.1	367
Mukene	62.7	7.0	24.7	9.0	2010
Nkejje	53.4	10.0	18.7	5.0	998
Lake flies	63.0	28.0	1.8	F	F

Comments or feed formulation

- There was need to increase the list of food ingredients. Rice bran was cheap and very abundant and contained high proportion of protein (about 9%). Also a number of cereals, legumes and some vegetations are available for supplementary feeding.

- Pond fertilisation with organic manure was very important in development of algae, zooplanktons and benthos. This supplies adequate protein to fish. Other source of protein could come from cropping excess fish in the ponds to replace expensive mukene.

- Marketing of formulated feed by Kajjansi would require conducting a diagnostic survey to assess the market potential. Generally many fish farmers enter fish farming activities with very low income.

- An ordinary meat mincer could be used to produce feed pellets which could be dried in an electric oven. Such feed pellets could be easily stored and used when required. A pelleting machine could be purchased later when funds are available.

Gaps

- Consideration of more locally available food ingredients.

- Feed evaluation on a variety of species.

- Effect of feeds on fry production.

- Data processing.

- Production of manual and booklets on feeding.

Constraints

- Inadequate funding
- Expensive mukene
- Machine for processing food ingredients
- Expensive Vitamin Premix
- Feed storage (Loss due to rodents, molds etc)
- Lack of equipment for biochemical analyses of foods.

Other Projects

The remaining three projects of the program have not been able to take of due to shortage of staff and inadequate funding. These include:

4.3. Pond productivity

- Its main objective was to identify and monitor chemical, physical and biological parameters that limit pond productivity.

4.4. Fish Stunting

- Major objective is to identify and study causes of stunting. Food and space have been a few causes considered.

4.5. Social Economics

The planned objectives of this project included

- Determine the costs of all input requirements of fish farming.
- Assess and quantify the productivity of fish farming in terms of harvested fish and examine its market competitiveness against fish from natural water bodies.
- Under take economic evaluation of alternative packages recommended to fish farmers.
- Assess other social economic factors that may influence the development of aquaculture.

Fish Farming Hand Book and Booklets:

Compilation of Fish Farming Handbook information was gathered through a meeting of all the technical staff at the station and the publication is expected early next year (1996). This draft highlighted transferable technologies from researchers to farmers through extension staff.

4.6. Results of Activities Aquaculture Program

4.6.1. Fry Production

Between January and December 1994 a total of 19,526 fish fry were produced and distributed to 14 districts. Shillings 344,500= was collected from sales of fry and shilling 215,000= owed by Agricultural Extension Project is still uncollected. See tables on Fry production and Fry distribution to districts.

Fry Production

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Oreochromis niloticus	1010	400	200	2160	1520	1790	620	700	800	100	500	1150
Cyprinus carpio	3004	-	1500	1770	480	-	-	72	170	500	-	-
T zillii	-	-	-	-	-	-	-	-	-	550	200	200
Haplochromis	-	-	-	-	-	-	-	-	-	-	-	200

Revenue Collected											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
60,000	12,000	45,000	30,000	18,000	45,000	18,000	13,500	7,500	33,000	22,500	40,000
	Total Revenue collected = 344,500										

Revenue Uncollected											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
40,000=	-	6,000=	96,000=	42,000=	-	-	6,000=	24,000=	-	-	-
	Total Revenue uncollected = 215,000=										

Fry: Total *Oreochromis niloticus* = 11,080=
Total *Cyprinus carpio* = 7,496=
Total *T. zillii* = 750=
Total Haplochromis = 200=
Total Fry = 19,526=
Total Revenue collected = 344,500=
Total Revenue uncollected = 215,000=

Fry Distribution to Districts

District	Cyprinus carpio	Oreochromis niloticus	Haplochromis	Total
1. Mbarara	1300	3396	-	4696
2. Mukono	1660	1730	-	3390
3. Rukungiri	-	2850	-	2850
4. Kitgum	1500	-	-	1500
5. Jinja	-	1254	-	1254
6. Hoima	1000	-	-	1000
7. Masaka	480	500	-	980
8. Luwero	72	700	-	772
9. Iganga	60	650	-	710
10.Kibale	700	-	-	700
11.Kabale	200	400	-	600
12. Masindi	10	390	-	400
13. Kampala	100	100	200	400
14. Mpigi	-	350	-	350
Total				19602

Fourteen districts received fish fry during the year. Mbarara district received the highest number of fish fry (4696) and Mpigi received the lowest (350).

4.6.2. Feed analysis

Food	Protein %	Carbo-hydrate %	Fat %	Fe ppm	Ca ppm
Maize grain	9.8	75.7	4.8	4.1	15.3
Maize bran	9.6	73.0	3.4	3.8	15.7
Brewery Waste	8.2	63.6	0.8	17.1	367
Mukene	62.7	7.0	24.7	9.0	3010
Nkejje	53.4	10.0	18.7	5.0	998
Lake flies	63.0	28.0	1.8	F	F

* F = Analysis failed

The following results were observed:-

- Protein content was higher in all animal tissues used than in plan tissues, protein content being highest in Lake flies,
- Carbohydrate content was higher in all plant tissues analysed than animal tissues - being highest in maize grain,
- Fat content was generally higher in animal tissues than plant tissue. However, extremely low values of fat were obtained in the Lake flies.
- High values of calcium occur in Mukene, Nkejje and Brewery.
- Further analyses of food ingredients in respect to vitamin revealed that only brewery waste contained vitamins A and C.
- Feed preparation and feeding testing

Generally feed was prepared in 30: 70 ratio of protein: Carbohydrate, but as the fish grew older feed preparation ratio changed to <30: >70 ratio to reduce in the high cost of protein food stuffs.

The station has not yet gone into specific testing of feeds on certain fish species. The emphasis has mainly been on proper and intensive feeding for rapid growth and production of fish fry.

CHAPTER 5

5. POST-HARVEST FISHERIES PROGRAM

Background

The program is concerned with the post harvest aspects fish/fish products after capture and processing up to the time fish reaches the consumer. All other programmes under FIRI are directly or indirectly concerned with increased and sustainable production of the fish resource. There is therefore need to optimally utilize whatever fish is produced and minimise post-harvest losses.

This program is vital to the country because it ensures high quality fish to consumers, income, employment for over 500,000 individuals, and the much needed foreign earnings through fish exports.

Post Harvest Production Constraints

The programme addresses the following constraints:-

- Poor preservation methods.
- Poor handling and processing techniques.
- Poor storage practices.
- Poor packaging and marketing facilities.
- Contamination by pathogenic spoilage micro-organisms.
- Inappropriate fishing methods.
- Consumer ignorance with respect to quality.
- Lack of product diversification.
- Chemical Contamination of fish.

Objective - Mandate

- The programme is mandated to improve Post harvest handling, processing, storage and marketing of fish and fishery products.
- Obtaining baseline data regarding the quality of fish currently on the market.

- Quantifying post-harvest losses in the fisheries sector.
- Developing quality assurance packages which will be used in effecting significant improvement in fish quality.
- Generating data concerning the nutritive value of fish species of commercial importance.
- Developing fish processing techniques aimed at optimal utilisation of the country's fisheries resources with due regard to conserving the environment.

5.1. Project in the Program

- **Improvement of fish handling, processing, packaging and storage facilities / practices.**

Observations

A considerable proportion of fish caught is lost post-harvest due to constraints outlined above. However no reliable data is available to indicate the quantities lost, though estimates put the losses at 20-30%.

Considering the importance of fish both as a food and a foreign exchange earner it is important that its quality is acceptable locally and internationally.

Studies under the Project

- Post harvest handling (Number and types of handling facilities, effects of the handling practices/facilities on the quality and shelf life of fish/fishery products)
- Processing (Number and type of processing techniques, conditions of operation. Effect on the quality and shelf life of fish/fishery products).
- Storage and packaging. Types of storage facilities, effects on the quality and shelf life appropriate storage conditions for different species.
- Marketing (Quality of fish on the market. Qualitative and quantitative losses along the Marketing Chain).

Major activities of Project

Prior to its incorporation into NARO (FIRI) the Post Harvest Program was more actively involved in extension than research. As such, it did not have on-going project(s) funded from within or without the country. The 1994, therefore has been a preparatory year.

However, during the late 1993 and early 1994 staff of the program were involved in an IDRC sponsored Fish Commodity Economic Systems Project (Fish Processing Component). In addition, they participated in the European Union sponsored survey of the current Fish Quality Assurance status in the country. It is worthwhile to note that these two surveys provided background information that was vital during the project proposal writing exercise for 1995/96.

Achievements - Outputs

- The program prepared some brochures the contents of which are summarised in 5.2.
- Some new laboratory equipment and chemicals were ordered through NAROSEC while some old pieces of equipment were repaired.

Constraints

Funding

At its inception under NARO the program did not have an on-going project which could have been funded either internally or by donors as explained earlier.

Staffing

The Program was under-staffed. There were four (4) technical staff (Senior Research Officer, Research Officer, Research Assistant and Senior Laboratory Technician) and five (5) support staff comprising of an Accounts Assistant, a Stenographer/Clerk, Driver, Cleaner and Office Messenger. The Research Assistant, Office Messenger and Cleaner only joined the program at the end of the year November/December.

Premises

The program was formerly housed in an isolated, insecure and dilapidated building at Kitubulu-Entebbe. It was so ill-equipped and poorly laid-out that it could not meet the demands of the proposed research objectives. It was therefore resolved that more suitable premises be sought. After prolonged negotiations with the Ministry of Trade and Industry lasting one year the program was offered laboratory and office space within the Industrial Research Institute for Food Technology and Ceramics at Nakawa. It was on temporary basis and under the auspices of the Uganda National Bureau of Standards (UNBS). On the 30th October, 1994 the program finally shifted to the new premises in Kampala. Given the terms of reference and the fact that the premises were quite new, there were some administrative constraints which hampered the smooth running of the program.

Summary of Program Constraints

- Delayed delivery of the requested equipment/chemicals by the NAROSEC.
- Delayed research funds to facilitate the execution of the approved studies.
- Under-staffing of technical personnel.
- Lack of a permanent home for the programme. This made physical planning difficult.

Future Research Plans

Project proposals in a standardized format were written and submitted to NARO secretariat for approval and subsequent funding. The projects were formulated in accordance with the programs overall objective, using the two surveys mentioned above as references. These will form the basis for future work.

Other Activities undertaken by Program Personel

Staff of the program were involved in the data analysis and report-writing of the IDRC sponsored Fish Commodity Systems project (Fish Processors Component). They also participated in the inspection of fish processing plants prior to number allocation which will facilitate fish exports to European Union. Furthermore the staff of the program were actively involved in the drafting of Food and Nutrition Policy and Plan of Action and a Modern Food Law. In addition brochures on the Post-Harvest Fisheries Program activities and fish handling were prepared.

Research Collaborations

The program has endeavoured to establish working relationship with various organisations and institutions within the country. For example Uganda National Bureau of Standard (UNBS), Departments of Biochemistry and Food Science and Technology of Makerere University. These two institutions have in principle, allowed the program to use their equipment and their personnel/students to participate in the Program's Research Projects. The laboratories at the Government Chemist have also been offered for use if need be, though at some cost. Furthermore, the program has corresponded with some universities in Canada, U.K, Netherlands and Denmark for the purpose of establishing collaborative research linkages. Due to the small number of scientists and lack of laboratory equipment/chemicals under the program, it was envisaged that collaboration of this nature would enhance and facilitate the execution of various experiments within the allotted time.

5.2. Results of Studies of the Program

5.2.1. Good Fish Handling Practices From Catch to Market

Introduction

Although estimates for post harvest losses are not properly quantified, considerable losses are experienced in the Fishing Industry.

The possible causes to these losses being poor handling of the fish at all the stages from fish catch, processing, storage distribution and marketing; the high ambient temperatures of the tropics the fish is subjected to, the rough handling including bruising the fish due to the fishing method and the poor infrastructure.

All these losses are due to spoilage of the fish which is caused by the digestive enzymes of the fish, the micro organisms living naturally on the fish or spread through contamination by man and by chemical means. The micro organisms play a leading role in fish spoilage. Since the organisms are mainly on the surface of the gills, intestines and the slime of the skin, and the surfaces with which the fish comes in contact, high standards of cleanliness at all stages of handling, processing, storage and distribution are essential.

Strict attention must be given to the efficient cleaning of the fish, the regular cleaning of all surfaces with which the fish come in contact, the provision of an uncontaminated water; supply and the hygiene of the fish handlers. These are important factors in good handling practices to ensure good quality wholesome fish.

The following recommendations for handling practices are essential at the various stages.

At fish capture

- Ensure the use of fishing methods which do not wound or bruise the fish, do not keep the fish for long hours before the fish is removed.

- Rinse the fish in lake water at the spot (off shore waters) to remove any possible contamination and sort and reject immediately the fish not fit for human consumption.

In the fishing vessel - Boat

- It is required that, the fishing vessel should be big enough, well painted, designed for efficient handling of the fish, easy to clean and disinfect and should not cause damage and contamination of the catch.

- The vessel should not contain sewage, bilge, fuel, oil or grease or any other objectionable matter which may contaminate the fish.

- For bigger fishing vessels, early on-board processing like gutting the fish, bleeding,

washing and the icing is essential, this reduces spoilage during holding time:

- Use only suitable equipment for the on-board processing.
- Apply only clean ice made from portable water which should not be contaminated.
- In case of lack of ice aboard, use clean wet burlap to cover the catch in order to keep it moist and from the high temperatures. High temperatures speed the rate of spoilage.
- Each step should be done very fast.

At landing sites; Transportation and Marketing

At landing sites fish handlers subject fish to fairly rough handling treatment which results in big quantities of spoilage. Fish quality deteriorates rapidly and potential keeping time is shortened. It is important that potential hazards associated with rough handling are avoided. The following are necessary at fish landing sites; during transit and markets:-

- Auctioning shade equipped with clean and portable running water, slabs on which fish is auctioned and cleaned and should be suitably located. Auctioning shade should be maintained clean.
- Clean insulated vehicles for the distribution of fish.
- Fish mongers should use clean plastic insulated boxes for carrying fish on bicycles and big enough to carry both ice and fish.
- Toilet facilities should be provided at landing sites.
- Fish handlers should have protective clothing and head gears
- Fish markets should be properly located in towns and should have running water; proper drainage system and suitable tables easy to clean and detect the dirt.
- Passengers should not be carried on vehicles carrying fish meant for human consumption or any other cargo.
- Fish displayed or in transit should always be properly iced to reduce the rate of spoilage.

CHAPTER 6

6. SOCIO-ECONOMICS PROGRAM

Background

The socio-economics program research seeks to contribute towards the broad goal of sustainable and efficient utilisation of aquatic resources for the maximum social and economic benefits with all the due considerations for the environment.

The program covers a broad range of issues cutting across all the Institute programs. During the prioritisation exercises undertaken during the year by NARO the following were identified as research priorities:

- Human interventions affecting fisheries resources,
- Inadequate information on the impact of fisheries production to national economy,
- Inadequate knowledge on the structure and functioning of fishing community,
- Insufficient knowledge of economic feasibility (of aquaculture practices)

However, it was later realised that the priorities in socio-economics did not come out satisfactory at FIRI as in all other Institutes. Consequently, NARO set up a special Task Force to make recommendations on the priority themes that would be addressed by socio-economic investigations at the different NARO Institutes. By the end of the year, the Task Force was continuing with its work.

However, the output of on-going investigations consists of information covering the following areas:

- Structure and functioning of fishing communities.
- Optimum levels of fisheries resource exploitation: social and economic issues.
- Cost of production, enterprise profitability and competitiveness of operating units.
- Assessment of technology alternatives and evaluation of economic losses.
- Fish marketing systems, demand, supply and consumption studies.
- Performance of the fishing industry.
- Macroeconomic and policy issues

Program Objectives

To provide information that would empower decision makers in the public, private and community circles to take appropriate decisions in the management, exploitation and utilisation of the fisheries resources.

The Projects in the Program

Three projects have continued to be implemented during the year, including:

- Fish commodity systems economics (Uganda) project
- East African great lakes project
- Use and protection of of water resources in Lake Victoria through sustainable management of wetland ecotones: socio-economic component.

6.1. Fish Commodity Systems Economics (U) Project

Introduction

The Fish Commodity Systems Economics (U) Project focuses on the socio-economic component of the Fisheries Research Institute programs. It is a three year project and was officially started in June 1992, with funding from the International Development Research Centre (IDRC) of Canada. Its overall goal is the improved economic performance in the fisheries sector.

Project Objective

The overall objective of the Project is to generate information that would facilitate and improve decisions and policies by the Government and private entrepreneurs in fisheries. Specific activities to accomplish the objective of the Project include:

- Undertake diagnostic studies of the fish producers, processors, marketing group and consumers.
- Contribution studies of Nile perch, Nile tilapia and *Mukene* fisheries to total GDP, employment, income and diet.
- A study into the utilisation of *Mukene*.
- Survey of the fishing enterprises.
- Studies of model fishing communities studies for the purpose of extracting lessons for adaption by other communities.

Methodological Guidelines

The project utilises the Production to Consumption Systems Research (PCSR) and both quantitative and qualitative methods including participatory research methodologies in its data collection. It further adapts the incremental research approach.

Implementation

The project came into effect in June, 1992. During the year under review, progress was achieved as outlined below:

Diagnostic Studies

Draft reports have been produced on the four sub studies, namely the study on producers, processors, the marketing group and consumers.

Contribution Studies

Draft reports have been produced on two contribution studies, namely contribution to diet and balance of payment studies.

Utilisation of *Rastrineobola argentea* (Mukene)

Detailed planning for the implementation of this study was undertaken and comprehensive data collection is now going on.

Enterprise studies

Detailed planning for the study have been completed. Due to inadequacy of logistics (transport), data collection has not began and is planned to start as soon as the field work under the Rastrineobola argentea study is completed.

Training

During the year, 2 Project researchers attended the 6th Participatory Rural Appraisal (PRA) course at Egerton University, at which they were introduced to PRA as a methodology for developing a Community Action Plan, commonly known as CAP with full participation of the beneficiary communities.

Linkages

The Project continued to foster linkages with all the major players in the fisheries industry as well as with institutions and personalities engaged in related work. As a result of this, the Project Leader had opportunity to attend workshops and discussions on various occasions during the year.

Constraints

A few problems have hindered the smooth implementation of the project as had been planned. These included:

- Field Allowances: Counterpart funds to supplement donor funds for field activities were not available until after July, 1994 and this limited data collection activities.
- Inadequate FIRI Personnel: FIRI researchers have not been adequate on the Project. As a result, much of the manpower was hired from outside making the Project's manpower cost high.
- Office Space: The Project has no sufficient office accommodation for its staff at FIRI.

Planned Activities

During the year 1995, the following will be undertaken:

- Preparation of a general diagnostic survey report.
- Studies on fisheries contribution to GDP, income and employment; and preparation of survey reports.
- A survey into the actual and potential utilisation of *Rastrineobola argentea* .
- A survey of fish production and processing enterprises.

6.2. East African Great Lakes Research Project

Background

The East African Great Lakes Research project is a collaborative research between FIRI and Michigan State University. It is funded by the Government of Uganda and McArthur Foundation. Its overall goal is the enhancement of the welbeing of fishing communities.

Objective

The overall objective of the project is to develop an understanding of the socio-economic impacts of the changes occurring in the fisheries of Lake Victoria on the lakeside communities.

The specific objectives of the collaborative activities being conducted under this project are as follows:

- to investigate the social and economic dimensions of the fisheries of Lake Victoria,
- to develop a plan for the collection, analysis, and dissemination of social and

economic data on the fisheries of Uganda, and

- to strengthen FIRI's research capabilities in the socio-economic dimensions of fisheries.

Activities and Status

The project began in May 1991 for an initial period of three years but due to implementation delays, it has been agreed that it would be extended. During the 1993/94 financial year, activities on the project were supported for 2 month solely by donor funding, as Government did not release any funds to the project during the year. However, the Project was included in the list of core projects in 1994/95 and from July 1994, funds from Government began to be received on the Project on a continuous basis.

By the beginning of the year 1994, activities undertaken included:

- Interviews with policy makers including heads of relevant Government departments, parastatals and private sector institutions;
- Interviews with policy and programme implementors;
- Interviews with community leaders and opinion leaders;
- Interviews at the fish processing and exporting firms;
- Boat census at the 9 identified research sites on Lake Victoria.
- Detailed interviews with boat owners, heads of crew and family members at 4 of the research sites.

Activities

- Detailed interviews with boat owners, heads of crews and family members at three (3) of the research sites:-
- Nabweyo/Busiro landings - Iganga District
- Kasensero landing - Rakai District
- Data entry
- Preparation of regular reports

Major Constraints

During the year, there were a few problems which hindered the implementation of the project

as had been planned:-

Implementation Delays

During the year, the monthly release of funds were not sufficient to make monthly field trips as had been planned. Whereas the Government releases of funds were in time, the actual payments were not effected promptly. This had an effect on project implementation plans.

Field Allowances

The monthly release of funds could not cover the field allowances and data entry costs. This has made it necessary to revise the field data collection plans, reducing the trips for the year to almost one third.

Transport facilities

The only vehicle provided for on the project has cost a lot in its operation and maintenance. This is much higher than envisaged, as a result of increasing fuel and spare costs.

Stationery and office expenses

The budget of the Project was considerably upset by heavy costs of stationery items, particularly to do with the production of questionnaires for the studies. Other office expenses included postage, DHL and fax charges. All these items were not provided for in the Project budget.

Incentive to respondents

The project has no provision for incentives for the respondents and guides who may at times assist researchers for long hours in the field.

Planned Activities

During the next year of the Project, it is intended to undertake the following project activities:

- Detailed interviews at the remaining research sites covering boat owners, heads of crew and family members;
- Interviews at all the research sites covering fish processors and dealers;
- Interviews at selected market centres with fish traders.
- Interviews at households with fish consumers;
- Follow up.

- Complete data processing and analysis
- Terminal workshop to discuss information so far obtained and its application.
- Write up final report

6.3. Wetland Ecotone Project.

Introduction

This is the social science component of a multi-disciplinary research project aimed at the utilisation of the ecotone wetlands for purification of water supply through sustainable community management and utilisation of the ecotone resources.
It is carried out in collaboration with the Institute of Ethnography, University of Zurich, Switzerland with funding support from the Swiss National Science Foundation.

Objectives

To study community utilisation of the ecotone resources with a view to building sustainable ecotone management into community practices and development processes.

Activities

Activities under the project include:

- Identifying the ecotone resource uses and users.
- Studying the ownership and property rights among the resource users.
- Learning of the indigenous knowledge among the resource users and their management practices.
- Studying the health issues associated with the ecotone resources including their use in traditional healing.

Expected Outputs

Expected outputs include information and knowledge on:

- Uses and users of ecotone resources.
- Land rights in the ecotone wetlands.
- Indigenous knowledge governing use of ecotone resources.
- Medicinal values of ecotone resources.

Implementation

Methodology

Data was collected by use of semi-structured questionnaires, interviews were conducted with various groups of resource users and uses. Interviews were also carried out with elders on land and property rights.

Respondents were randomly selected but giving equal chances to both men and women. The areas of sample were Kirinya swamps and Budumbuli swamp in Jinja. Garden survey and measurement were conducted using the following methods, pacing, "bucket method" and using a tape measure. Most of the gardens were measured to find the extent at which man has encroached on the swamps.

The Project started in June 1994 and during this period the following activities were carried out:-

- Interviews were carried out in the 3 swamps in Jinja namely Loco, Walukuba and Budumbuli to study the interaction of the lake side communities with the ecotone resources. Questionnaires were designed to cover different categories of wetland users such as cultivators, fishermen, those who collect medicinal herbs, soil dye for decorating houses, gathering firewood, hunters and also brick makers.

- During the interviews, the greatest number of respondents were found to be involved in agricultural activities. The next activity was to carry on with garden survey in order to assess the extent of the wetland which has been encroached on by man. As a result various gardens in the different swamps were measured using three major ways namely pacing, bucket method and also using a measuring tape.

- In the gardens, the techniques of gardening were also observed and it was found out that most of the cultivators practised intercropping due to limited land and crop rotation was the major method used in soil conservation. Most gardens had drainage with heaps and with furrows to protect the crops from floods that occur during heavy rains.

- Interviews with elders were also carried out to find out more on the existing land rights and it was realised that the wetland belonged to Jinja Municipal but with no specific regulation on the usage of the ecotones and most of the respondents acquired it through free access on the basis of "first come first serve".

- Swamp fishing was surveyed and the different fish species were found to be tilapia, mud fish and Nile perch. Research revealed that tilapia was the leading species because they breed in the swamps. It was found out that women only participate in post-harvest activities such as fish processing.

- Craftsmaking was also identified and this activity was done by women during their leisure time.

- Interviews were carried out with traditional healers who gathered their herbs from the ecotones.

- On the other hand, interviews were done with respondents who collected soil for medicine and dye to decorate houses.

Constraints

- Disbursement of funds were often not very regular and data collection was often hindered as a result of this.

- Inadequate Transport Facilities: Bicycles were availed to the researchers to enable them carry out research activities but due to some of the long distances to cover, they were often not appropriate, especially during the rainy seasons.

- Difficulty in obtaining information from some respondents due to misinformation on the aim of the survey.

- Seasonal floods: Floods during the rainy season delayed and made activities like measuring gardens difficult.

Planned Activities

During the year 1995 it is intended to complete the following activities:

- Preliminary survey of research areas.

- Training in participatory research methodology.

- Study of Ecotone resource uses and users.

- Paper on property rights in the ecotone areas.

- Indigenous knowledge study.

- Health study.

All the above activities are also going to be carried out in a rural area (Ssese Islands) in order to make a better comparison.

6.4. Results of Socio-economics Studies

6.4.1. Features of Production and Distribution in the Uganda Fisheries Sub-sector

By O.K. Odongkara & O.J. Amule

Introduction

During the 1994/95 financial year, the fisheries sub-sector in Uganda contributed some 105 billion Shillings towards the GDP, according to official statistics. The sub-sector grew at 8% over the previous year, close to the national growth rate of 10% and well above the agricultural sector growth rate of about 6% during the same period. The sub-sector earned some US $ 15 million from an estimated export of 117 Metric Tones of fish. Employment was put at over 500,000 and post harvest losses amounted to 20% of production.

In an effort to find ways of strengthening performance in the fisheries sub-sector, a diagnostic study has recently been done under the Fish Commodity Systems Economics (U) Project. The study covered span across the sector components, using the Production to Consumption System Research (PCSR). Using a nation-wide sample survey, interviews with key respondents and secondary data, information was put together about the main components of the sub-sector and the major constraints.

Summary of Findings

- Fish production and distribution is actively carried out mostly by people of the economically productive age bracket of 18-35 (42.0% of respondents among producers, 52.3% of processors and 69.4% of traders).

- Level of literacy varied across the board with 56% of producers reporting attaining primary education level, 50% among artisanal processors and 55.1% for the marketing group.

- Women participation was found to be limited at 6.6% among producers, and 11.8% among fish traders.

- Ownership of units was mainly private.

- Motivation in fish related activities was mainly the desire to earn income.

- Resources required for the activities of the different operators included labour, fish as a raw material, firewood, capital, gear and crafts.

- Producers used nets and hooks of average size of 4.7" and hook number 7.8 respectively with average fleet numbers of 15 nets and 365 hooks. Access to formal credit to the operators was very limited with the exception of the industrial processors.

- Many acquired capital and credit through informal borrowing from friends and family members.

- Formal organisation was rare among most operators except the Industrial processors who belonged to the Uganda Fish Processors & Export Association. However, some operators reported belonging to some co-operative societies, namely the traders (4.3%) and producers (29.2%). Reasons for reluctance to join associations were mainly lack of funds, poor administration, corruption and embezzlement and ignorance on co-operative benefits. Informal collaboration and arrangements such as borrowing of essential inputs, assistance to members in need and settling disputes, however, featured.

- Apart from the Industrial processors which are mainly located in the urban towns of Kampala, Jinja and Entebbe, access to well developed infrastructure facilities were either poor or fair to most operators. Electricity, piped water, storage, banking, postal, health centres, accommodation, toilet, disposal of waste products and fish handling facilities were reported to be either poor or fair.

- Units involved in fish production and distribution consisted of 1-5 people while the industrial processors often employed not less than fifty depending on the size of plant. Most respondents had been engaged in their respective activities for a period exceeding five years and many expressed the intention of continuing in their jobs.

- Limited technology characterised all the sub sector activities except Industrial processing which had the necessary equipment and technology pertaining to a fish plant. Most operators had crude and traditional technology. However, in limited cases, producers used outboard engines.

- As stated above, the fisheries sub sector contributed to national income, employment, tax revenues and export earnings as well as provision of cheap animal protein necessary in people's diet. Negative impacts on the environment was through disposal of disused materials and industrial waste either in the open or the water systems. Producers also degrade fish stocks through indiscriminate fishing.

- Fish consumers on the other hand obtained their supplies from traders (62%), fishermen (26%) and a few of the elite class depended on imported fish (3.1%). The levels of fish consumption was found to vary with region and family size, estimated at 200 kg per annum for Kalangala District and 2kg for Kabale and Rukungiri. Fish was preferred as the first sauce (39.2% of respondents), followed by beans (24.0%) and meat (20.0%). Frequency of fish consumption rated mostly at once in over two weeks (48.6%), daily (16.9%), once a week (18.5%) and once in two weeks (7.6%).

- Various factors were noted to influence fish consumption which included steady income of the consumer, distance from and access to source of fish, population densities, cultural factors and taboos and consumer preference.

6.4.2. Fishing Outfit Ownership, Management and Operation

By O.K. Odongkara & J.W. Mulabe

Introduction

As part of the activities to follow up the impact of the changes in the fisheries of Lake Victoria on the fishing communities, a study was made into the fishing outfits operated by the fisherfolk. The study was done under the East African Great Lakes project The objective was to provide an understanding of the craft and gear in use with respect to the ownership structure, the management and their operation.

A boat census was done at identified research sites on lake
Victoria and subsequently data was collected using structured questionnaires.

The following categories of people were interviewed:

- Community leaders and opinion leaders
- Boat owners, heads of crews and family members
- Processors and traders.
- Local formal leaders, heads of fish organization, officials of local community Government
- Co-operative officials, fisheries extension officers
- Non-fishing households in the community and comparable data on personal background and household activities.

The research sites were selected from a sample of beaches from five ecological zones on Lake Victoria, idendified by
Witheral (1972) namely:-

Zone I — From Uganda-Tanzania border to Bunjako bay.

Zone II — The Ssese Islands.

Zone III — From Bunjako bay to Rosebury channel (Entebbe region)

Zone IV — From Rosebury channel to 15 miles east of Jinja town (including western part of Buvuma)

Zone V — From 15 miles east of Jinja to Kenya border.

Summary results

Several changes that have occurred in the fisheries of Lake Victoria over the last several

years. Some of the major changes include reduction in fish species composition, changes in the fish biomass on the lake, changes in water quality and level and climatic variations.

The impact of these changes on the fisherfolk have varied in its dimensions.

In the area of fishing outfits, several types of boats have been developed for use by the fishermen in response to the changing fisheries resource situations.. They have included the dug-out canoes(1%), planked parachuttes and the Sseses(98%), all of varying sizes, and increased use of the outboard motor (43%) for exploitationa of distant waters and for increased carrying capacity has become evident.

The fishermen have varied the use of different types of gear, including beach seines, mosquito seines, purse seines, liftnets, dipnets, gillnets, castnets and hooks. The use of pressure lamps for fishing *Rastrineobola argentea* has also increased.

Because of the varying availability of fish in the Lake, more of the above mentioned outfits have been put to use. Given the migratory behaviour of fish, this has led to high levels of migration of the fishermen from one site to another in search of fish.

The changes in the fisheries of lake Victoria, have contributed to the increasing numbers of fishermen and more fishing outfits are deployed in response to the changes. In the process, poor fishing methods have often been used.

It was noted that the great number of boats and gear were operated by owners who took 62% of the decisions on what species to fish and where to fish them.

The boat owners mobilised capital resources of which 66% are from personal savings.They also borrow from friends and relatives and to a limited extent from financial institutions. They also employed labour, both managerial and operators whom they paid in terms of cash or shares depending on the catch.

6.4.3. Ecotone Resource Utilisation

By O.K. Odongkara, G. Rupiny, J. Mugote & A. Nassuuna)

Background

The utilisation of the ecotones, locally known as the lakeside swamps, has recently increased with the recent awareness of their value and the population pressure created on the limited land. Man has encroached on the ecotones in order to meet his livelihood.

The swamps are used in agriculture; swamp soil is used as dye for decorating houses; the reeds (phragmites and typha) help in promoting crafts industry, herbs and also act as a breeding ground for fish especially the tilapia and Nile perch species.

Objective

To study the utilisation of the ecotone resources, protection and conservation with a view to building sustainable wetland management practises.

Summary of Findings

- The main resource users were cultivators (78%), growing mainly sugarcane, potatoes, maize and vegetables, followed by fishermen (16%), while other users constituted 6%. Crops grown were mostly for home consumption (86%); the surplus of 14% is for sale in the local markets.

- Fishing covers (16%) as a resource use and fish species caught include Tilapias (15%), *Clarias* (14%), *Protopterus* (6%) and other species (5%).

- Different age groups were identified with the most involved ranging within the bracket of 18-35 years (71%); others constituted 29%. The illiteracy level within the espondents was very low.
- 53% of the resource users work throughout the year while 47% work occasionally.

- Women involvement in wetlands resource use dominated (63%) while men constitute only 37% since they are more involved in the fishing activity.

- The main reason for the resource users having embarked seriously on depriving the swamps of their natural vegetation was found to be famine (40%) followed by the increased population pressure on land (23%), poverty (15%) and ecological reasons.

- 68% of the resource users were affected by wildlife that destroyed their crops or posed a threat to their lives. The main wildlife types included monkeys, mole rats, squirrels, hippos, crocodiles and monitor lizards.

- ther risks in the wetlands included theft of crops and health hazards, mainly bilharzia and malaria.

- Land in the wetlands was utilised through free access by most resource users (68%) whereas some resource users (32%) acquired it as private property by paying rent for the land or by mutual negotiations in either cash or kind.

- Some users also drain the wetlands in the process of using them. However, the competition between those who use the wetlands as wetlands and those who drain them does not seem to be a big problem.

- There seemed to be no clear regulations governing the use of the wetlands. 98% of the users reported not to be organised into any organisation that would supervise the use of the resources.

7. APPENDICES

Appendix 1. Long and Short-term Training undertaken during 1994.

Long term training

Dr. Ogutu-Ohwayo, R. completed his PhD. at the University of Manitoba, Canada and three officers started PhD programs: Mr. Balirwa, J. registered for PhD. at IHE, Delft The Netherlands; Mr. Ndawula, L. at Vienna University, Austria; and Mr. Mbahinzireki, G. at Ohio State University, USA.

Five Research Assistants (Mr. Charles Olet-Ogwang, Ms Gertrude Namulemo, Mr. James Ojwang-Okor, Mr. Erasmus Twinomujuni and Ms Joyce Akumu) started MSc training at Makerere University. FIRI scientist and some visiting scientists were involved in giving lecture/courses to M.Sc. students of Makerere University and also in supervising graduate students.

Short term Training

Mrs Ruth Byekwaso attended a course at the Inservice Training Centre for Secretarial Development Course

Mr. J.O. Okaronon attended the International Course on "Data Handling for Tropical Fisheries Management" at the International Agricultural Centre, Wageningen.

Mr. L. Muhoozi and Mr Masifwa were at the Institute of Limnology in Austria for Postgraduate Training Course in Limnology.

Mr. Stephen Ssekiranda went for a Diploma Course at IHE, Delft.

Appendix 2. Workshops and other Meetings

Mr. J.O. Okaronon participated at the regional seminar held in Entebbe to draw up a unified form to be used for catch/effort data collection on Lake Victoria. This form was used during the training courses for data collectors on Lake Victoria (9 - 10 March 1994)

Dr. F.W.B. Bugenyi, Dr. T.K. Twongo and Mr. J.O. Okaronon were in Mwanza, Tanzania, to participate at (1) the 9th Project Management Committee meeting and (2) the Workshop on the formulation of the second Phase of the project (9 - 16 April 1994).

Dr Ogutu-Ohwayo, R., Attended a workshop on: Fishs stock assessment in inalnd Fisheries, University of Hull, England, April 11-15th, 1994.

Dr. Ssali also attended a sub-regional workshop on mycotoxins other than aflatoxins, at the University of Botswana, Gaborone, 12th - 16th December 1994.

Staff of the Post Harvest Fisheries Program participated in many relevant workshops and

meetings which included FAO Fish Quality/Assurance Seminar, NARO Workshops, FIRI Meetings, UNBS Workshops and Seminars.

A number of project personnel participated at the 10th Project Management Committee meeting and the Lake Victoria Fisheries Organization meeting (called by FAO) held in Jinja(16 - 19 August 1994)
Project personnel participated at The National Agricultural and Trade Show in Jinja (5 - 10 July 1994).

Attended the 10th management committee meeting on Lake Victoria, training needs assessment seminar at NARO headquarters and various HARE ASAC, EEC and program meetings.

Participated in FTI (Fisheries Training Institute) curriculum review workshop

Experimental gear selectivity trials were completed for Lake Victoria and review of literature, past data done for lakes Victoria, Kyoga and Nabugabo.

Disseminated the preliminary fishing technology package to fisheries extension staff at Mukono DFI workshop and to public during the shows

Appendix 3. List of brochures produced by FIRI scientists during 1994.

Fisheries Research Institute, Mandate and Activities.

The Fisheries Program.

Lake Victoria Fish Stock Assessment.

Impact of Nile Perch on Fishery Yield and Fish Species Diversity.

The Mukene Fishery.

Guidelines on types of fishing gears and methods for exploitating Nile perch, Tilapias and Mukene

Conservation of Endangered Native Fishes in Lakes Victoria and Kyoga

Appendix 4. The list of publications by FIRI scientists during 1994.

Balirwa, J.B. ??. The Lake Victoria environment - its wetlands and fisheries: a review: was submitted and accepted for publication in the journal *Wetlands Ecology & Management*.

Balirwa, J.B. ??. Ecological implications of human activity-induced changes for the Lake Victoria fisheries: was presented at the 6th International Congress of Ecology in August in Manchester, UK.

Hecky, R.E, Bugenyi, F.W.B., Ochumba, P. Talling, J.F., Mugidde, R., Gophen, M., and

M. Kaufman . Deoxygenation of the hypolimnion of Lake Victoria. Limnology and Oceanography Vol 3:(6) 1994.

Hecky, R.E., H.A. Bootsma, R.Mugidde and F.W.B.Bugenyi. 1994. Phosphorus pumps, Nitrogen Sinks, and Silicon Drains; Pumping nutrients in the African Great Lakes in the press" " in "The Limnology, Climatology, and Palaeoclimatology of the East African Lakes".

Ogutu-Ohwayo, R., 1994. Adjustments in fish stocks and in life history parameters characteristics of Nile perch, *Lates niloticus* L. in Lakes Victoria, Kyoga and Nabugabo. PhD thesis. University of Manitoba. 213pp.

Appendix 5. Visitors to the Institute

The Institute received many foreign and local visitors who came in for various reasons. Notable among them were the following:-

Prof. Fritz Schiemer with a team of Scientists and Ecological Excursion and supervising PhD candidate.

EU Lake Victoria Fisheries Projects consultants comprising Drs Fritz Roest, B. Bennett, P.Degubol, J. Moreau and E. Elefthrakis
Dr. R. Roijackers form Wageningen Agriculture University

Prof. P. Denny IHE, Supervising PhD.

Dr. H. Ven Bruggen from IHE for discuss Wetland research project proposal.

Prof. J.S. Mothersill from Canada on Paleolimnological investigations on Uganda Lakes.

Dr. M. Van der Knaap, Coordinator, EU Lake Victoria Fisheries Project Coordinator visited on the coordination of the project.

Dr. Markus Wolf and Corrine Walker, Swiss scientitsts of the Ecotone Project

NARO Board Prof. I.B. Kayanja, Mr.C. Kabuga, Prof. H.S.K. Nsubuga, Mrs. Gava, Dr. T.C. Bamusonighe, Mr. J. Ogwang,
Mr. W.O. Otage. Dr. S.L. Nsubuga, on a familiarisation tour of the institute

Drs M. Kalunda & Dr. F. Orach-Meza on Familiarization visit

Dr. L. Bagnall on EU Water hyacinth consultancy mission.

Drs. G. Neuville, J.Baraza, G. Hill, on familiarisation tour

Drs. Laureen & J. Chapman collaborative scientists from University of Florida.

Dr. George Kling, Dr.Peter Reinthal, Y. Psilanti, Jose Romero,
Tom Bridgman, Patricia Ramlal; USA scientists on the Lake Victoria Ecosystem Project.

Drs R.E. Hecky, B. Davy and L. Navarro to discuss IDRC / FIRI Project

Mr. D. Fadda of FAO Rome came to discuss the LVFO Headquarters agreement.

Prof. Winn J.Wolff, supervision J. Balirwa's PhD program Ph.D.

Bishop C. Bamwoze to get acquainted with the work of the institute.

Mr. G. Ssentongo, FAO Rome, to prepare meeting of Lake Victoria Management Committee meeting and Lake Victoria Fisheries Organization.

World Bank Mission comprising Drs Quisumbing, M.M. Rahman, M. Kalunda, F. Orach-Meza, R.C.M. Cruul, Prof. J. Okedi and Mr. M.C.M. Dhatemwa to discuss findings of Dr. Cruul.

Prof. Dan Livingstone, G.H. Debusk Y.B. Parashkevov
Dr. J. Mworia, collaborative scientists to collect cores from Lakes Edward and George.

Prof. J. Lehman, collaborative scientists to continue collection of data on Biodiversity and Climate Change.

Scientists from EU, IDEAL, UNESCO, World Bank, UNEP, TAFIRI, KMFRI comprising Mr. Manfred Brandt, Mr. E.G. Ring, Prof. T. Johnson, Mrs Radha Singh, Dr. Takechiro Nakumura, Dr. E. Naah, Dr. M. Van der Knaap, Mr. E. Katunzi, Prof. P. Bwathondi, Mr. T. Maembe, Mr.A. Moire, Mr. J. Ogari, Mr. D. Mukiibi and
Dr. L. Talabi; to attend Lake Victoria Management Committee.

Dr. L.K. Akap, Tender for production of Uganda "Fisheries Master Plan".

Hon. Jackson Makwetta, Minister of Agriculture, Tanzania.

Hon. Zachary Olum, Hon. Namujangu, Hon. K.A Latigo-Olal of NRC Sectoral Committee on Agriculture and Mr. S. Amayo from from MAAIF visited to Acquaintance with work of the Agriculture.

DANIDA Consultant Mission on acquatic resources comprising Drs Suend Lindc, Per Posmussen, Naginder, Ahmed and Mr Bahaar.

Dr. P.Onoles FIRI on Information strategy.

Mr. Nico Van Maurik and Mr. Madaza Lizhibowa came to assist in computer training and studies of waste water treatment.

Dr. G. Kling, Programme of the Ecosystem Project.

Drs. Denny & Dr. H. van Bruggen came to discuss wetlands study proposals and to supervise Mr Balirwa's PhD program.